

## **Biological Assessment and Sediment Study**

### **Mill Creek Lincoln County, Missouri**

**2008**

Prepared for:

Missouri Department of Natural Resources  
Division of Environmental Quality  
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Appendix A	Statistical Analyses Comparing Benthic Sediment Estimates Between Sampling Stations. Kruskal-Wallis ANOVA on Ranks and Dunn's Multiple Comparison Test was used to Test Differences in the Percent of the Stream Bottom covered by Benthic Sediment between the Sampling Stations
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## 1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**), Water Protection Program (**WPP**), Water Pollution Control Branch (**WPCB**), the Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate bioassessment and benthic fine sediment study of Mill Creek in Lincoln County. A five mile segment of Mill Creek near the town of Silex was assessed. Macroinvertebrates were collected at two stations during the spring and fall 2008 sampling seasons. Macroinvertebrates were also collected at five small candidate reference streams located within the Central Plains/Cuivre/Salt Ecological Drainage Unit (**EDU**) that were similar in size and character. These small streams were included because Mill Creek is much smaller than the biological criteria reference streams in the Central Plains/Cuivre/Salt **EDU** and may not have a comparable macroinvertebrate community because of stream size. Benthic sediment deposits covering the stream bottom at the two stations were visually estimated during the fall 2008 sampling season.

## 1.1 Study Area/Justification

Mill Creek is a tributary of the North Fork Cuivre River that originates in northwest Lincoln County and is contained within the Central Plains/Cuivre/Salt Ecological Drainage Unit (**EDU**). Mill Creek discharges into the North Fork Cuivre River near the town of Silex and is listed in the Missouri Water Quality Standards (MDNR 2008) as a class "C" stream for five miles.

Designated uses for Mill Creek are "warm water aquatic life protection, livestock and wildlife watering, and designation B for whole body contact recreation." The five miles that are classified as class "C" on Mill Creek have been placed on the 2002 303(d) list for elevated levels of sediment.

Mill Creek is located within the Lincoln Hills section of the Glaciated Plains natural division (Thom and Wilson, 1980). The Lincoln Hills are Ozark-like in topography, geology, and biological fauna. It is characterized by steep topography and geology from the Ordovician and Mississippian ages. Springs and karst features are common in Lincoln Hills compared to other sections in the Glaciated Plains natural division. Mill Creek, like other streams in the Lincoln Hills, is a riffle/pool stream with clear water and bottom substrates made up primarily of gravel and cobble. The fish fauna that occurs in Mill Creek is dominated by species that commonly occur in the Ozark streams based on one sample collected in 1962 and two samples collected in 1989 (Missouri Department of Conservation, 1993). Some examples of the fish species that have been collected in Mill Creek are the banded sculpin (*Cottus carolinae*), bigeye shiner (*Notropis boops*), northern hog sucker (*Hypentelium nigricans*), and slender madtom (*Noturus exilis*).

## 1.2 Purposes

- 1) To determine if the macroinvertebrate community in Mill Creek is impaired.
- 2) To determine if benthic fine sediment is elevated in Mill Creek compared to the small candidate reference streams.

### **1.3 Tasks**

- 1) Conduct a biological assessment of the macroinvertebrate community on Mill Creek at two stations and at the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU during the spring and fall 2008 sampling seasons.
- 2) Conduct a stream habitat assessment at the sampling stations to ensure comparability of aquatic habitats.
- 3) Visually estimate the percentage of the stream bottom that is covered by fine sediment at Mill Creek and the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU during the fall 2008 sampling season.

### **1.4 Null Hypotheses**

- 1) The macroinvertebrate community will not differ between longitudinally separate reaches of Mill Creek.
- 2) The macroinvertebrate community in Mill Creek will not differ from data collected from the riffle/pool biological criteria reference streams in the Central Plains/Cuivre/Salt EDU.
- 3) The macroinvertebrate community in Mill Creek will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU.
- 4) The stream habitat assessment scores will not differ among longitudinally separate reaches of Mill Creek.
- 5) The stream habitat assessment scores will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU.
- 6) The visual estimates of the percentage of fine sediment covering the stream bottom in Mill Creek will not differ among longitudinally separate reaches of Mill Creek.
- 7) The visual estimates of the percentage of fine sediment covering the stream bottom in Mill Creek will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU.

## **2.0 Methods**

Carl Wakefield, Dave Michaelson, and Brandy Bergthold of the Missouri Department of Natural Resources, Division of Environmental Quality, Environmental Services Program, Water Quality Monitoring Section conducted this study.

### **2.1 Study Timing**

Macroinvertebrate and discrete water quality samples were collected once at each sampling station during the spring and fall 2008 sampling seasons. A stream habitat assessment was conducted at the sampling stations on May 6-7, 2008 and visual estimates of fine sediment were

conducted during the 2008 fall sampling season. Spring sampling was conducted on April 2-3, 2008 and fall sampling was conducted from September 29 to October 1, 2008.

## **2.2 Station Descriptions**

Two Mill Creek test stations and five small candidate reference streams from the Central Plains/Cuivre/Salt EDU were sampled for this study. See Figure 1 for the locations of the Mill Creek test stations, Figure 2 for the locations of the small candidate reference streams, and Table 1 for stream classification and size characteristics for all of the sampling stations.

### **2.2.1 Sampling Stations**

Mill Creek #1 – Lincoln County: Legal description was SE 1/4, sec. 6, T. 50 N., R. 1 W. Geographic coordinates were UTM zone 15, 668301 Easting, 4332603 Northing. Station located upstream of the confluence of Dry Branch, which receives Silex WWTF effluent discharge.

Mill Creek #2 – Lincoln County: Legal description was NE 1/4, sec. 5, T. 50 N., R. 1 W. Geographic coordinates were UTM zone 15, 670205 Easting, 4333212 Northing. Station located at the southern end of the William R. Logan Conservation Area.

Big Creek #1 – Warren County: Legal description was NW 1/4, sec. 34, T. 48 N., R. 2 W. Geographic coordinates were UTM zone 15, 662317 Easting, 4305582 Northing. Station upstream of North Church Rock Road.

Sugar Creek #1 – Lincoln County: Legal description was NW 1/4, sec. 31, T. 50 N., R. 1 E. Geographic coordinates were UTM zone 15, 67738 Easting, 4325175 Northing. Station located in Cuivre River State Park upstream of Highway KK.

Brush Creek #1 – Ralls County: Legal description was SW 1/4, sec. 30, T. 55 N., R. 4 W. Geographic coordinates were UTM zone 15, 637659 Easting, 4374302 Northing. Station upstream of Bison Drive

Hays Creek #1 – Ralls County: Legal description was NW 1/4, sec. 29, T. 54 N., R. 5 W. Geographic coordinates were UTM zone 15, 629917 Easting, 4366398 Northing. Station upstream of Bridgewater Lane.

Grassy Creek #1 – Pike County: Legal description was SW 1/4, sec. 9, T. 54 N., R. 2 W. Geographic coordinates were UTM zone 15, 661028 Easting, 4369805 Northing. Station upstream of County Road 135.

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Table 1

Stream Classification and Size Variables for Mill Creek Bioassessment Study Sampling Stations

	Mill Ck. #1	Mill Ck. #2	Big Ck. #1	Sugar Ck. #1	Grassy Ck. #1	Hays Ck. #1	Brush Ck. #1
WQ Standards Classification	Class C	Class C	Class C	Class C	Unclassified	Class C	Unclassified
Stream Order	3	3	3	3	3	3	3
Shreve Link	11	9	6	11	9	13	6
Watershed Size (mi <sup>2</sup> )	10.47	8.29	18.55	14.97	11.01	12.68	7.74

## 2.3 MoRap Aquatic Ecological Classification

The aquatic ecological classification developed by the Missouri Resource Assessment Partnership (**MoRAP**) is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa et al., 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic subregions, EDU, Aquatic Ecological Systems (**AES**), and Valley Segment Types (**VST**). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify and other levels use biology and taxonomic composition of aquatic communities. Ecological Drainage Units and AES are the two levels of the classification that will be assessed in detail for this study.

### 2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and based on geographical variation of the taxonomic composition of the level 4 subregions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. A map of the Central Plains/Cuivre/Salt EDU is inset in Figure 1. The Mill Creek sampling stations are within this EDU. Table 2 compares the land cover percentages from the Central Plains/Cuivre/Salt EDU and within the watersheds of the sampling stations upstream of the sampling locations. Land cover data were derived from Thematic Mapper satellite data from 2000 to 2004 for the entire EDU and from the 2001 national landcover database for the sampling station watersheds. Forest cover was much higher in the Mill Creek watershed than the entire Central Plains/Cuivre/Salt EDU and higher than the other small candidate reference streams except Grassy Creek. Cropland was higher in Hays and Brush creeks than the Mill Creek test stations and the other small candidate reference streams.

### 2.3.2 Aquatic Ecological Systems

Aquatic Ecological Systems are level six of the classification hierarchy and classify aquatic systems into AES types based on geology, soils, landform, and groundwater influence. Mill Creek is located in the Upper Cuivre River AES type (Figure 2). Local relief is less than 197 feet and headwater/creek mean gradient is 58 feet per mile for this AES type. Soil texture is silt loams with slow to moderate infiltration rates and the soils are underlain by Mississippian and

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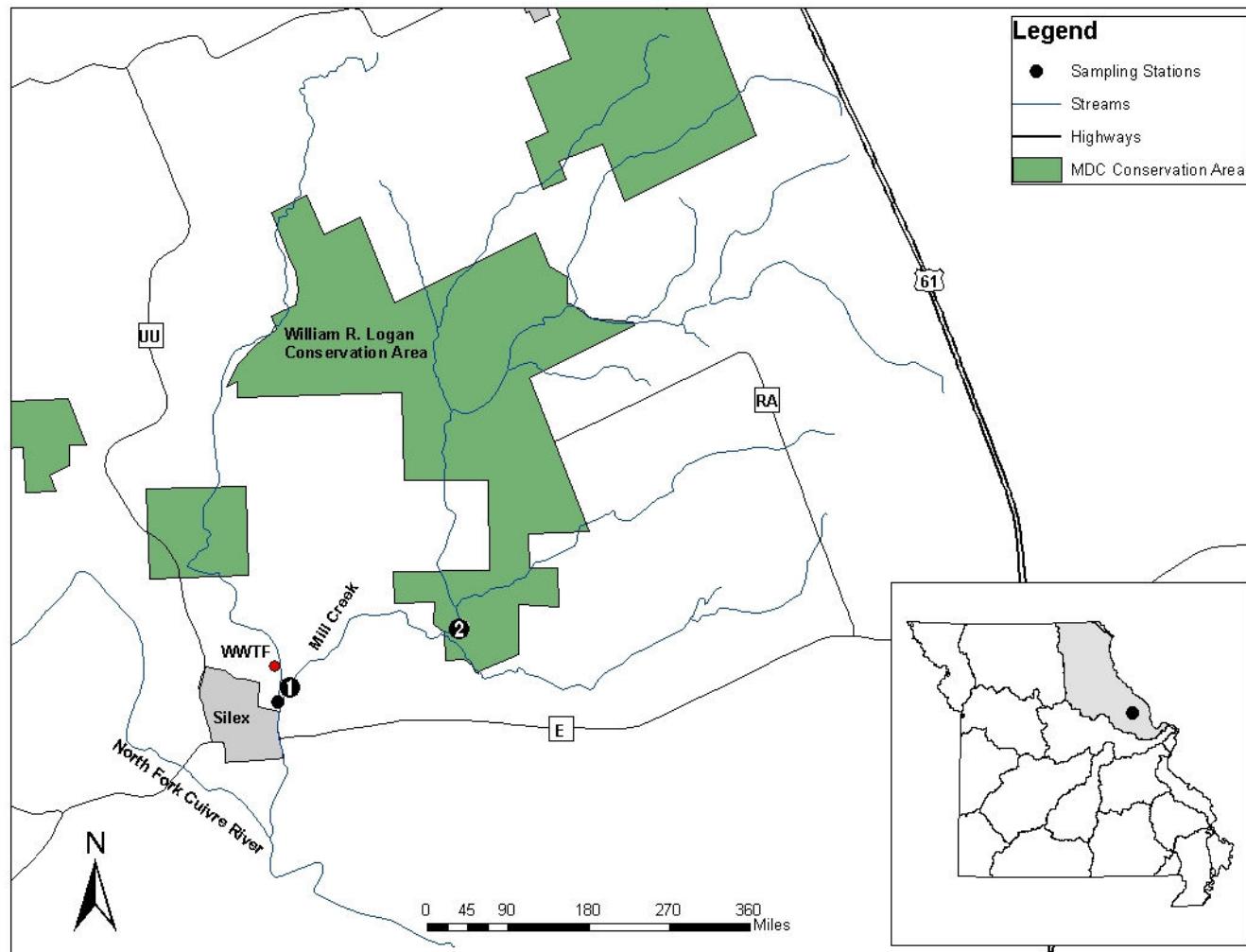
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Ordovician limestones with small amounts of sandstone (Sowa and Diamond, 2006). Coldwater habitat is an important feature to this AES type compared to other AES types in the Central Plains/Cuivre/Salt EDU. There are 75 headwater/creek springs in this AES type, including a spring at the Mill Creek #2 sampling station.

Four of the small candidate reference streams, Big, Brush, Sugar, and Hays creeks, are located within the Lick Creek AES type. The small candidate reference streams are located in the eastern portion of this AES type, which is similar to Ozark border areas compared to the rest of the AES type. This eastern section of the Lick Creek AES has soil texture made up of silt loams with slow to moderate infiltration rates and the soils are underlain by Ordovician sandstones and limestones. Karst features like sinkhole ponds are present in the eastern section of Lick Creek AES and topography can range from rolling to rugged. The western section of the Lick Creek AES is much more prairie-like than the eastern section, with stream channels made up of silt and clays that are meandering low gradient streams with narrow watersheds. The western section of the Lick Creek AES is made up primarily of Pennsylvanian limestones that transition to Mississippian limestone nearer to the Mississippi River. Claypan soils on a flat to gently rolling topography are common in the western section of the AES type. Most of the local relief for the entire Lick Creek AES is 98 feet, but occasionally approaches 197 feet in some locations and the mean headwater/creek gradient is 40 feet per mile.

One of the small candidate reference streams, Grassy Creek, is located in the Ramsey Creek AES type. This AES type is made up of streams that are Ozark-like with many of them being small Mississippi River tributaries that begin on the Mississippi River bluffs and flow down across the Mississippi River floodplain. Local relief ranges from nearly zero in the floodplain to occasionally more than 295 feet on the Mississippi River bluffs. The mean gradient is 55 feet per mile for headwater/creeks. Geology is composed of Ordovician sandstones and limestones for Ramsey Creek AES units that occur in the Central Plains/Cuivre/Salt EDU. Soils are diverse and variable in this AES type depending on the parent material from which they were formed. Surface soil textures typically consist of silt loams and silty clays with moderate to slow or very slow infiltration rates. The Grassy Creek watershed is made up of silt loams with moderately well drained infiltration rates. Most of the streams are headwaters and creeks that are deeply incised with gravel substrates. Groundwater is abundant, but springs are not. There are 64 headwater/creek springs scattered across 22 individual Ramsey Creek AES units.

Figure 1  
Map of Mill Creek and Sampling Stations



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Figure 2

Aquatic Ecological Systems (AES) Types for Mill Creek and the Five Small Candidate Regional Reference Streams in the Central Plains/Cuivre/Salt EDU

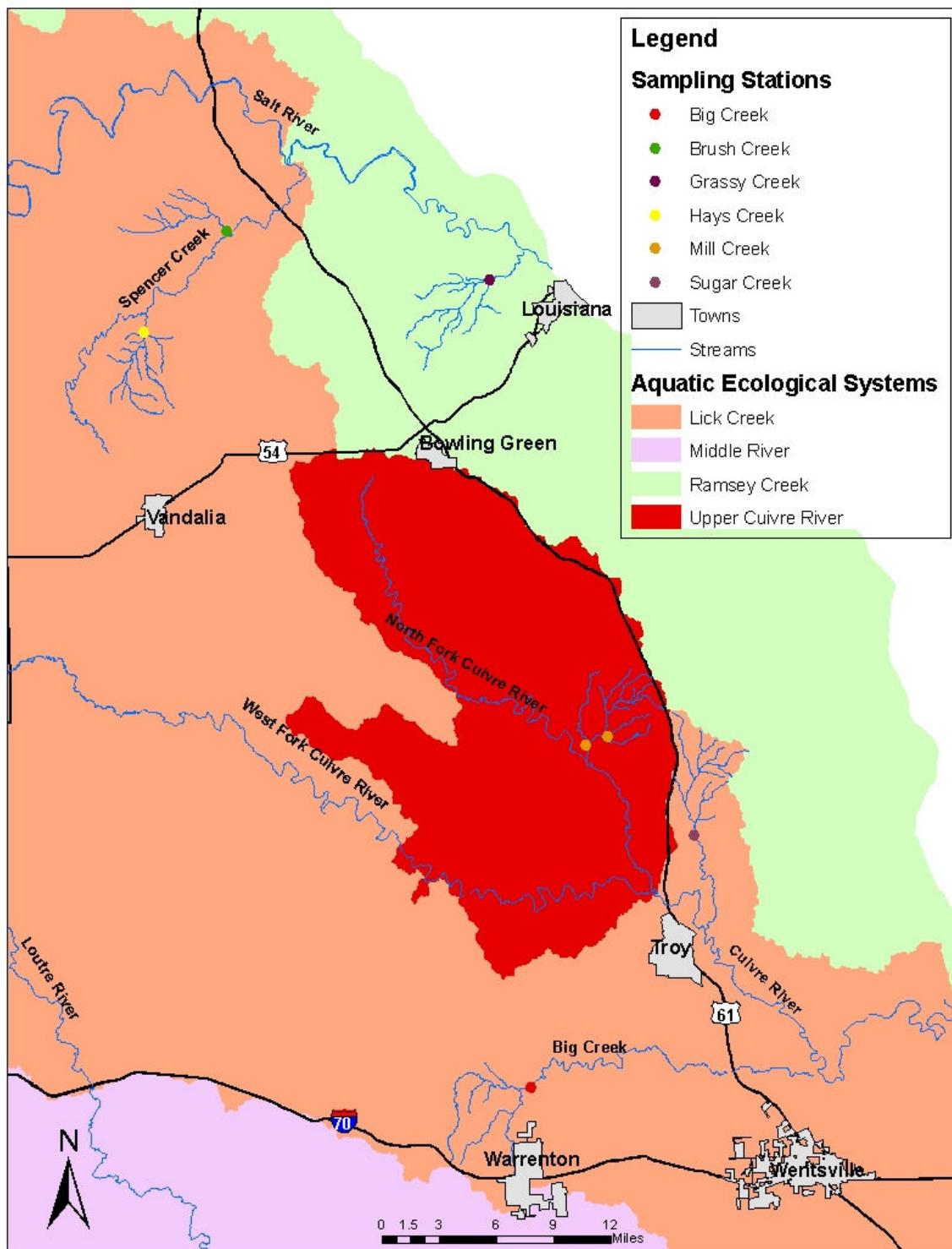


Table 2  
Percent Land Cover

Land Cover	Urban	Crops	Grassland	Forest	Wetland
Central Plains/Cuivre/Salt EDU	3	42	23	32	1
Mill Creek #1	4	18	30	48	0
Mill Creek #2	4	19	26	50	0
Big Creek #1	9	22	21	46	1
Brush Creek #1	4	40	31	24	1
Hays Creek #1	4	53	19	23	1
Grassy Creek #1	4	15	25	56	0
Sugar Creek #1	4	25	32	39	0

## 2.4 Stream Habitat Assessment

A standardized assessment procedure was followed as described for riffle/pool habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2003a). The habitat assessment was conducted on all stations during May 2008.

## 2.5 Visual Estimation of Benthic Sediment

Benthic sediment covering the stream bottom was visually estimated using the methods described in the draft standard operating procedure MDNR-WQMS 115, Percent Estimation of Fine Sediment Substrate in Streams (MDNR 2007). Percent fine sediment (particle size less than 2 mm) covering the stream bottom was visually estimated within a metal quadrat (25 cm X 25 cm) at Mill Creek and the five small candidate regional reference sample reaches. The estimates were made at three sample grids within each sample reach and located at the upper end of pools just downstream of riffle/run habitat where stream velocity was less than or equal to 0.5 cfs

(Figure 3). A sample grid consisted of six contiguous transects across the stream. A transect was established by stretching a tape measure from bank to bank and sampled in a downstream to upstream direction. A sample quadrat was placed directly on the substrate within each of the six transects using a random number that equated to one-foot increments (Figure 3). Two investigators visually estimated the percentage of the stream bottom covered by fine sediment within each quadrat. If the sediment estimates by the two investigators were within ten percent of each other, the estimate was accepted. If the estimates differed by more than ten percent, the investigators repeated the process until the estimates were within ten percent of each other. An average of the two estimates was then recorded and used for analysis.

The benthic sediment data were assessed using two statistical methods with the SigmaStat program (version 3.5, 2006). The first method was to assess the sediment data using a Kruskal-Wallis One Way Analysis of Variance (ANOVA) on Ranks without combining any of the data into test or control groups. The second method combined the sediment data from the small candidate reference streams into a control group and compared it to each of the Mill Creek test stations using a Kruskal-Wallis One Way ANOVA on Ranks. Both of these methods were used to determine percent sediment differences between sites and to find out if the Mill Creek test stations were significantly different ( $P < 0.05$ ) from the small candidate reference streams.

## 2.6 Biological Assessment

Biological assessments consist of macroinvertebrate collection and physicochemical sampling for two sample periods.

### 2.6.1 Macroinvertebrate Collection and Analysis

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP) (2003b) for riffle/pool (RP) streams. Three standard habitats, flowing water over coarse substrate (CS), depositional substrate in non-flowing water (NF), and root-mat (RM), were collected at the sampling stations.

Macroinvertebrate data were analyzed using three methods. The first analysis was to calculate the Missouri Stream Condition Index (MSCI) using the biological criteria for perennial/wadeable streams from the Central Plains/Cuivre/Salt EDU using the four general biological metrics found in the SMSBPP (MDNR 2001; MDNR 2002). The four general biological metrics used and found in the SMSBPP are: 1) Taxa Richness (TR); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (EPTT); 3) Biotic Index (BI); and 4) Shannon Diversity Index (SDI).

The second analysis was calculating MSCI scores using the macroinvertebrate data collected from the five small candidate reference streams from the Central Plains/Cuivre/Salt EDU using the four general biological metrics found in the SMSBPP. The metric criteria used in the MSCI were calculated using samples from 2008 and 2009 for the spring sampling season, but only 2008 data for the fall sampling season. Three of the five small candidate reference streams were resampled during the spring 2009 sampling season for another bioassessment project and were

included in the small stream criteria for the spring sampling season. This analysis was done to determine whether stream size was important in assessing the impairment of Mill Creek using the macroinvertebrate community since the sampling stations were much smaller than the perennial/wadeable biological criteria reference streams used to calculate biological criteria for the Central Plains/Cuivre/Salt EDU.

The third analysis was an evaluation of macroinvertebrate community composition by percent composition of EPT, functional feeding groups (FFG), functional habitat groups (FHG), and the most abundant macroinvertebrate families and taxa. Comparisons of the macroinvertebrate community of the Mill Creek test stations and the small candidate regional reference streams were then made.

## **2.7 Physicochemical Water Sample Collection and Analysis**

Results are shown from discrete physicochemical collections and analyses during each of the macroinvertebrate sampling periods in 2008 (Tables 14 and 15).

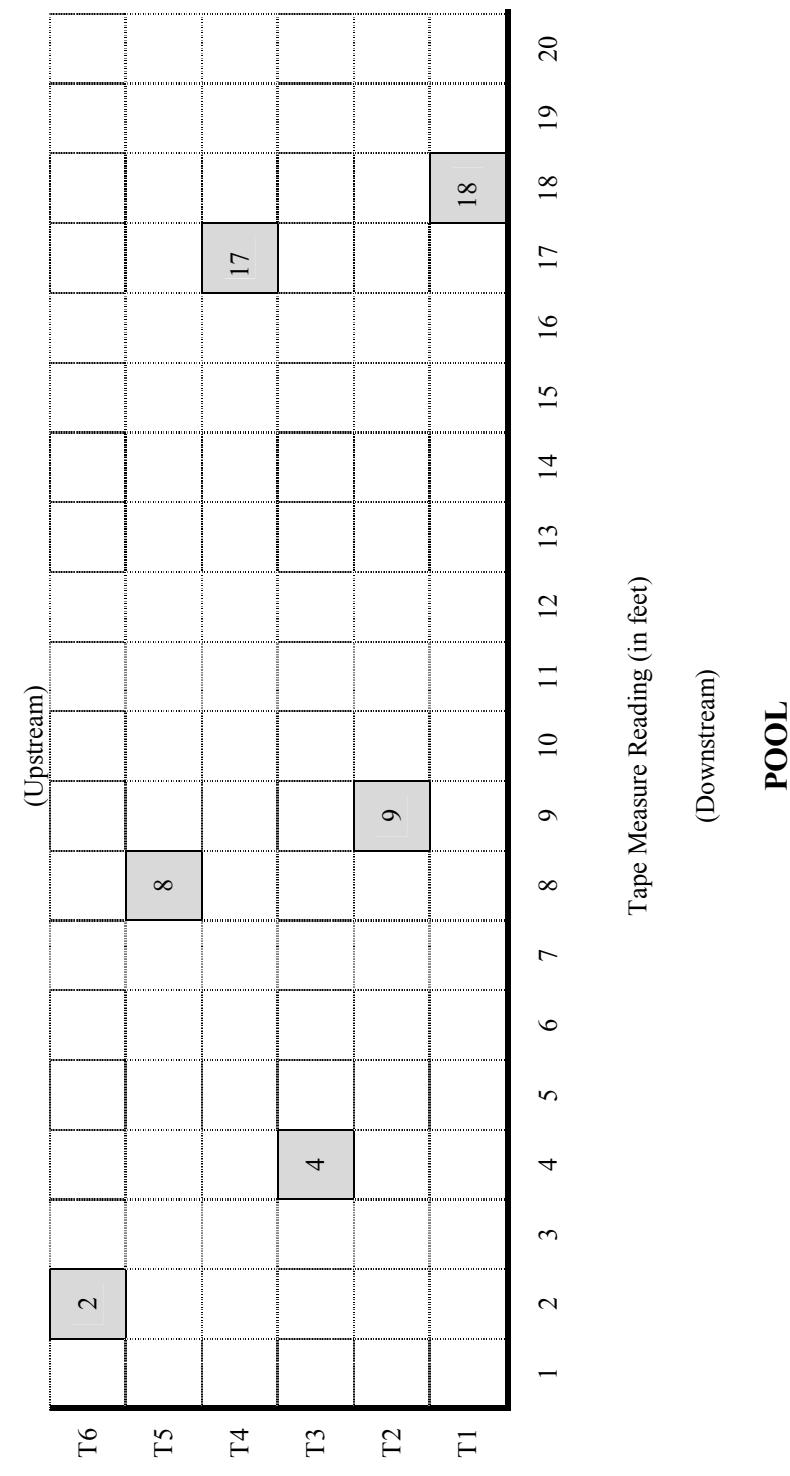
Discrete physicochemical samples collected during the spring and fall 2008 sampling seasons were: pH, temperature, conductivity, dissolved oxygen, discharge, turbidity, ammonia-N, nitrate+nitrite-N, total nitrogen, chloride, and total phosphorus. Temperature, pH, conductivity, dissolved oxygen, and discharge were conducted in the field. All samples were collected per MDNR-FSS-001: Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2003c), were kept on ice until they were delivered to the ESP laboratory, and were recorded on a chain-of-custody per MDNR-ESP-002 (MDNR 2005).

Results of water quality analyses were compared to Water Quality Standards (MDNR 2008). Mill Creek is classified as a class "C" stream and a general warm-water fishery (GWWF) for the study reach. Waters designated as GWWF "allow the maintenance of a wide variety of warm-water biota, including naturally reproducing recreationally important fish species."

### **2.7.1 Discharge**

Stream flow was measured using a Marsh-McBirney Flow Meter at each station and discharge was calculated as cubic feet per second (cfs). Methodology was in accordance with the standard operating procedure MDNR-WQMS 113, Flow Measurement in Open Channels (MDNR 2003d).

Figure 3  
Virtual grid of transects (T) and quadrats (in gray, numbered) for  
estimating percent fine sediment  
Example: stream 20' wide; quadrats placed by selecting random numbers (e.g. 18, 9, 4, 17, 8, 2)



## **2.8 Data Analysis and Quality Control**

The physicochemical data were examined by variable to identify stations that had violations of the Missouri Water Quality Standards (MDNR 2008). Sampling stations that had values that were higher or lower than the water quality standards will be discussed with possible influences being identified.

Quality control was used as stated in the various MDNR Project Procedures and Standard Operating Procedures. Duplicate samples at Hays Creek #1 during the fall 2008 sampling season were collected for macroinvertebrate and physicochemical parameters. A random number of processed macroinvertebrate collections were rechecked for missed specimens.

## **3.0 Results**

### **3.1 Stream Habitat Assessment**

Table 3 provides habitat assessment scores for the Mill Creek test stations and the small candidate reference streams in the Central Plains/Cuivre/Salt EDU. Data were collected in May 2008 with Carl Wakefield and Dave Michaelson performing the scoring. SHAPP guidance states that test stations scoring at least 75 percent of the total score of reference/control stations should support a similar biological community. Based on the habitat scores, the Mill Creek test stations should support a similar biological community as found in the small candidate reference streams since the habitat scores were higher than the average score of 139.5 that was estimated at the small candidate reference streams.

Most of the habitat metrics in the SHAPP at the Mill Creek test stations did not indicate habitat impairment. Only two habitat metrics in the SHAPP, vegetative protection and riparian zone width, scored in the marginal category at Mill Creek #1. One metric, vegetative protection, scored in the poor category at Mill Creek #2. Most of the metric values at the test stations were comparable to the values at the sampling stations located at the small candidate reference streams.

### **3.2 Visual Estimate of Benthic Sediment**

Benthic sediment measurements using the visual estimation method are presented in Table 4 and the results of the Kruskal-Wallis One Way ANOVA on Ranks are shown in Table 5, Appendix A, and Appendix B. The sediment data were analyzed in two ways and all significant differences between sampling stations were at the  $p<0.05$  level. The first analysis compared sediment data of the sampling stations individually and the second analysis pooled the small candidate reference stream data into a control group that was then compared to the Mill Creek test stations. The second analysis was done to compare differences between the Mill Creek test stations and the average conditions at the small candidate reference streams, even though Grassy Creek was significantly different than two of the small candidate reference streams.

The first analysis showed that Mill Creek #2 had significantly higher benthic sediment estimates than Mill Creek #1 (Tables 3 and 4). The visual estimation method does not measure sediment volume, but it should be mentioned that the upstream grid (grid #3) at Mill Creek #2 was located on a slab of bedrock that was covered by a very fine layer of silt. As a result, the actual amount

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of sediment at Mill Creek #2 was probably lower than the visual estimates suggest since 5 of 6 transects in grid #3 were very high. The visual estimate of benthic sediment was highest at Brush Creek with a mean value of 76.5 percent (Table 4). It had a significantly higher amount of benthic sediment coverage than the test station at Mill Creek #1 and two of the small candidate reference streams, Big Creek #1 and Sugar Creek #1. Grassy Creek #1 also had a high amount of sediment covering the stream with a mean value of 60.6 percent and was significantly higher than Mill Creek #1 (Table 5).

The second analysis showed that Mill Creek #1 had a significantly lower amount of benthic sediment coverage compared to the control group, but there was no significant difference in the sediment estimates between Mill Creek #2 and the control group (Table 5).

Table 3  
 Predominant Category Habitat Values and Total Habitat Scores from Stream Habitat Assessments for the Mill Creek Test Stations and the Sampling Stations at the Small Candidate Reference Streams

	Mill Creek #1	Mill Creek #2	Big Creek #1	Sugar Creek #1	Hays Creek #1	Brush Creek #1	Grassy Creek #1
<b>Sample Date</b>	05/06/08	05/06/08	05/06/08	05/07/08	05/06/08	05/06/08	05/06/08
<b>Stream Habitat Parameters</b>							
Epifaunal Substrate/Available Cover	II (40.5)	II (42.0)	I (61.0)	III (23.5)	II (31.5)	III (25.5)	III (26.5)
Embeddedness	I	I	I	I	II	I	I
Velocity/Depth Regime	II	I	II	I	II	III	II
Sediment Deposition	II (9.5)	II (11.5)	II (15.0)	II (7.0)	II (18.0)	III (32.0)	II (8.0)
Channel Flow Status	II	III	III	III	III	III	III
Channel Alteration	I	I	I	I	I	I	I
Riffle Quality	II	I	II	II	II	III	III
Bank Stability – Left Bank	I	II	II	I	I	I	I
Bank Stability – Right Bank	I	I	I	I	II	I	I
Vegetative Protection – Left Bank	III (59.5)	IV (35.5)	III (68.0)	IV (42.0)	II (71.0)	III (54.0)	III (67.0)
Vegetative Protection – Right Bank	III (66.0)	IV (35.0)	IV (30.5)	IV (48.0)	IV (26.5)	III (50.5)	IV (43.0)
Riparian Zone Width – Left Bank	III	I	I	I	I	I	I
Riparian Zone Width – Right Bank	III	I	I	I	I	I	I
<b>Total Habitat Score</b>	143	145	147	143	135	133	140

Mean values are listed in parentheses for habitat parameters in which a mean value was calculated. Habitat parameter categories ranged from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor.

Table 4  
 Percentage of Benthic Sediment Observed per Grid and Quadrat Using Visual Estimation Method at the Mill Creek Test Stations and  
 the Sampling Stations at the Small Candidate Reference Streams, Fall 2008

Grid Number- Quadrat Number	Mill Creek #1	Mill Creek #2	Big Creek	Sugar Creek #1	Hays Creek #1	Brush Creek #1	Grassy Creek #1
1-1	5.0	62.5	2.5	27.5	100.0	100.0	85.0
1-2	1.0	100.0	8.5	5.0	2.0	100.0	5.0
1-3	2.5	100.0	0.0	32.5	100.0	100.0	60.0
1-4	1.0	100.0	0.0	90.0	100.0	98.0	92.5
1-5	1.0	5.0	0.0	62.5	98.0	99.0	92.5
1-6	0.0	95.0	3.0	10.0	1.0	100.0	90.0
2-1	82.5	3.0	77.5	4.0	62.5	10.0	99.0
2-2	2.5	20.0	45.0	3.0	12.5	57.5	90.0
2-3	82.5	2.5	97.0	0.0	20.0	17.5	87.5
2-4	6.0	0.5	42.5	32.5	25.0	42.5	15.0
2-5	19.0	2.5	67.5	0.0	4.0	77.5	60.0
2-6	4.0	5.0	100.0	0.0	10.0	100.0	62.5
3-1	10.0	96.5	0.0	0.0	10.0	85.0	42.5
3-2	5.0	91.5	62.5	3.0	17.5	100.0	10.0
3-3	17.5	96.5	67.5	2.5	17.5	5.0	70.0
3-4	0.0	26.5	25.0	90.0	17.5	90.0	0.00
3-5	5.0	96.5	37.5	1.0	6.5	98.0	42.5
3-6	40.0	100.0	65.0	82.5	87.5	96.5	87.5
<b>Mean</b>	15.8	55.8	38.9	24.8	38.4	76.5	60.6
<b>Standard Deviation</b>	26.15	45.03	35.4	33.3	39.8	34.2	33.8

Table 5

Statistical Sediment Estimate Comparisons Using the Kruskal-Wallis One Way ANOVA on Ranks and Dunn's Multiple Comparison Test for the Mill Creek Test Stations and the Sampling Stations at the Small Candidate Reference Streams

<b>Data Comparison (Median in Parentheses)- Small Regional Reference Stream Stations not Combined in a Control Group</b>	<b>Dunn's Multiple Comparison Test P-Value</b>
Brush Creek #1 (97.3) vs. Mill Creek #1 (5.0)	<b>&lt;0.05</b>
Brush Creek #1 (97.3) vs. Sugar Creek #1 (4.5)	<b>&lt;0.05</b>
Brush Creek #1 (97.3) vs. Big Creek #1 (40.0)	<b>&lt;0.05</b>
Brush Creek #1 (97.3) vs. Hays Creek #1 (17.5)	>0.05
Brush Creek #1 (97.3) vs. Mill Creek #2 (77.0)	>0.05
Brush Creek #1 (97.3) vs. Grassy Creek #1 (66.3)	>0.05
Grassy Creek #1 (66.3) vs. Mill Creek #1 (5.0)	<b>&lt;0.05</b>
Grassy Creek #1 (66.3) vs. Sugar Creek #1 (4.5)	>0.05
Grassy Creek #1 (66.3) vs. Big Creek #1 (40.0)	>0.05
Grassy Creek #1 (66.3) vs. Hays Creek #1 (17.5)	>0.05
Grassy Creek #1 (66.3) vs. Mill Creek #2 (77.0)	>0.05
Mill Creek #2 (77.0) vs. Mill Creek #1 (5.0)	<b>&lt;0.05</b>
Mill Creek #2 (77.0) vs. Sugar Creek #1 (4.5)	>0.05
Mill Creek #2 (77.0) vs. Big Creek #1 (40.0)	>0.05
Mill Creek #2 (77.0) vs. Hays Creek #1 (17.5)	>0.05
Hays Creek #1 (17.5) vs. Mill Creek #1 (5.0)	>0.05
Hays Creek #1 (17.5) vs. Big Creek #1 (40.0)	>0.05
Big Creek #1 (40.0) vs. Mill Creek #1 (5.0)	>0.05
Big Creek #1 (40.0) vs. Sugar Creek #1 (4.5)	>0.05
Sugar Creek #1 (4.5) vs. Mill Creek #1 (5.0)	>0.05
<b>Data Comparisons (Median in Parentheses)- Small Regional Reference Stream Stations Combined into a Control Group</b>	
Mill Creek #1 (5.0) vs. Control Group (42.5)	<b>&lt;0.05</b>
Mill Creek #2 (77.0) vs. Control Group (42.5)	>0.05

Dunn's multiple comparison test p-values in bold are significantly different

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## 3.3 Macroinvertebrate Biological Assessment

### 3.3.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

Missouri Stream Condition Index (**MSCI**) was calculated at the Mill Creek test stations using both the biological criteria from the perennial/wadeable reference streams and criteria calculated from the macroinvertebrate data collected at the small candidate reference streams. The two assessments were done to determine if stream size was a determining factor of the macroinvertebrate community since Mill Creek was much smaller than the biological criteria perennial wadeable reference streams.

The MSCI scores using the perennial/wadeable biological criteria from the Central Plains/Cuivre/Salt EDU for the spring 2008 and 2009 sampling seasons are shown in Table 6 and the fall 2008 sampling season are shown in Table 7. Three of the five small candidate reference streams were sampled again during the spring of 2009 as part of another biological assessment study and their results are included in Tables 6 and 8 since the samples were used to calculate the small candidate reference stream criteria. All of the Mill Creek test stations and the small candidate reference stations had MSCI scores in the partial support category during the spring 2008 sampling season, ranging from 10-14. Taxa richness (TR) and EPT were much lower at most of the sampling stations compared to perennial/wadeable biological criteria. Shannon Diversity Index (SDI) was much lower at all of the sampling stations compared to the biological criteria. Big Creek #1 and Brush Creek #1 were the only stations that had values close to the fully supporting category for the TR and EPT metrics. Mill Creek #2, Sugar Creek #1, and Grassy Creek #1 had very low TR, EPT, and SDI values which led to very low MSCI scores ranging from 8 to 10. Biotic Index (BI) was the only metric at the sampling stations, except at Big Creek #1, that scored in the fully supporting category.

The spring 2009 results from the samples collected at the three small candidate reference streams showed that the individual biological metric values were generally higher than the spring 2008 results, but Sugar Creek #1 was the only sampling station that had a higher MSCI Score. Sugar Creek #1 had an MSCI score in the partial supporting category with a score of 10 during the spring 2008 sampling season, but the MSCI score for spring 2009 was in the fully supporting category with a score of 16. All of the spring 2009 metric values at Sugar Creek #1, except biotic index, indicated that the stream had a more diverse and balanced macroinvertebrate community compared to the spring 2008 results.

All of the sampling stations, except Big Creek #1, had MSCI scores during the fall 2008 sampling season in the partial support category, ranging from 10 to 16 (Table 7). Metric values for each sampling station were generally higher during the fall sampling season compared to the metric values for the spring 2008 sampling season. Taxa Richness and SDI, in particular, were much higher at the three stations (Mill Creek #2, Grassy Creek #1, and Sugar Creek #1) that had a very low MSCI score of 10 during the spring 2008 sampling season. Biotic Index was higher at all of the sampling stations, except Big Creek, compared to the spring 2008 sampling season, which indicated a more tolerant macroinvertebrate community. Even though some of the metric values showed improvement during the fall 2008 sampling season compared to the spring 2008

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sampling season, the MSCI scores indicated that the quality of the macroinvertebrate community was not as diverse and balanced as the perennial/wadeable biological criteria reference streams. The only exceptions occurred at Big Creek #1 during the fall 2008 sampling season and Sugar Creek #1 during the spring 2009 sampling season since the two samples had MSCI scores of 16.

The MSCI scores using biological criteria calculated from the small candidate reference streams located within the Central Plains/Cuivre/Salt EDU for the spring 2008 and 2009 sampling seasons are shown in Table 8 and the fall 2008 sampling season are shown in Table 9. Based on the small reference stream criteria, Mill Creek #2, Sugar Creek #1, Grassy Creek #1, and Hays Creek #1 had MSCI scores in the partial support category during the spring 2008 sampling season (Table 8). Mill Creek #1, Big Creek #1, and Brush Creek #1 had MSCI scores in the fully supporting category. All of the samples that scored in the partial support category, except Hays Creek #1, had TR and SDI values that were much lower than the other sampling stations. Hays Creek was just on the border between the partially supporting and fully supporting categories since it could have scored a 20 if the TR and EPTT were 1 taxa higher and the SDI 0.01 unit higher.

All three of the small candidate reference streams that were sampled during the spring 2009 sampling season had MSCI scores in the fully supporting category using the small candidate reference stream criteria (Table 8). Sugar and Hays creeks had MSCI scores of 20 during the spring 2009 sampling season, which were much higher than the MSCI scores of 14 that two streams had during the spring 2008 sampling season. All of the Big Creek samples from both the spring 2008 and 2009 sampling seasons had MSCI scores of 18. Sugar Creek showed the most improvement between sample years with TR increasing from 36 to 68, EPTT increasing from 8 to 20, and SDI increasing from 1.87 to 2.83.

The Mill Creek test stations and Hays Creek #1b had MSCI scores in the partial supporting category during the fall 2008 sampling season using criteria calculated from the data collected at the small candidate reference sampling stations (Table 9). The other sampling stations had MSCI scores in the fully supporting category. The three sampling stations that had MSCI scores in the partial supporting category had slightly lower values for TR, EPT, and SDI than the other sampling stations.

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Table 6  
 Central Plains/Cuivre/Salt EDU Perennial/Wadeable Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Mill Creek Bioassessment Study Sampling Stations for the Spring 2008 and 2009 Sampling Seasons

Stream and Station Number	Sample Date	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Mill Creek #1	04/02/08	0804144	51	8	5.20	2.16	12	P
Mill Creek #2	04/02/08	0804145	31	6	4.90	1.60	8	P
Big Creek #1	04/02/08	0804142	72	12	8.00	2.46	12	P
Sugar Creek	04/02/08	0804143	36	8	5.50	1.87	10	P
Grassy Creek #1	04/03/08	0804146	37	8	5.30	2.01	10	P
Brush Creek #1	04/03/08	0804147	67	13	6.30	2.73	12	P
Hays Creek #1	04/03/08	0804148	50	10	5.80	2.32	14	P
Big Creek #1a	03/23/09	0930021	69	14	6.40	3.14	12	P
Big Creek #1b	03/23/09	0930022	69	14	6.50	3.15	12	P
Sugar Creek #1	03/23/09	0930023	68	20	6.10	2.83	16	F
Hays Creek #1	03/23/09	0930025	68	13	6.20	3.21	14	P
Metric Score=5	If	>77	>17	<6.30	>3.21	20-16	Full	
Metric Score=3	If	77-39	17-9	6.30-8.10	3.21-1.61	14-10	Partial	
Metric Score=1	If	<39	<9	>8.10	<1.61	8-4	Non	

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=5); TR=taxa richness; EPTT=Ephephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 7  
 Central Plains/Cuivre/Salt EDU Perennial/Wadeable Biological Criteria, Biological Support  
 Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Mill Creek  
 Bioassessment Study Sampling Stations for the Fall 2008 Sampling Season

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Mill Creek #1	0804093	65	9	6.60	2.62	12	P
Mill Creek #2	0804092	60	12	6.90	2.70	12	P
Big Creek #1	0804094	76	15	6.60	3.25	16	F
Sugar Creek	0804095	67	10	6.60	2.97	12	P
Grassy Creek #1	0804099	67	12	6.30	2.73	12	P
Brush Creek #1	0804098	66	10	6.60	3.00	14	P
Hays Creek #1a	0804096	67	9	7.00	2.79	12	P
Hays Creek #1b	0804097	57	8	6.9	2.54	10	P
Metric Score=5	If	>73	>17	<6.33	>2.99	20-16	Full
Metric Score=3	If	73-37	17-9	6.30-8.10	2.99-1.49	14-10	Partial
Metric Score=1	If	<37	<9	>8.10	<1.49	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=5); TR=taxa richness;  
 EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 8  
 Central Plains/Cuivre/Salt EDU Small Candidate Reference Stream Biological Support Categories, and  
 Macroinvertebrate Stream Condition Index (MSCI) Scores at the Mill Creek Bioassessment Study Sampling Stations for the Spring  
 2008 and 2009 Sampling Seasons

Stream and Station Number	Sample Date	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Mill Creek #1	04/02/08	0804144	51	8	5.20	2.16	16	F
Mill Creek #2	04/02/08	0804145	31	6	4.90	1.60	14	P
Big Creek #1	04/02/08	0804142	72	12	8.00	2.46	18	F
Sugar Creek	04/02/08	0804143	36	8	5.50	1.87	14	P
Grassy Creek #1	04/03/08	0804146	37	8	5.30	2.01	14	P
Brush Creek #1	04/03/08	0804147	67	13	6.30	2.73	20	F
Hays Creek #1	04/03/08	0804148	50	10	5.80	2.32	14	P
Big Creek #1a	03/23/09	0930021	69	14	6.40	3.14	18	F
Big Creek #1b	03/23/09	0930022	69	14	6.50	3.15	18	F
Sugar Creek #1	03/23/09	0930023	68	20	6.10	2.83	20	F
Hays Creek #1	03/23/09	0930025	68	13	6.20	3.21	20	F
Metric Score=5	If	>50	>10	<6.40	>2.32	20-16	Full	
Metric Score=3	If	50-25	10-5	6.40-8.20	2.32-1.16	14-10	Partial	
Metric Score=1	If	<25	<59	>8.20	<1.16	8-4	Non	

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=5); TR=taxa richness; EPTT=Epphemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 9  
 Central Plains/Cuivre/Salt EDU Small Candidate Reference Stream Biological Criteria,  
 Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at  
 the Mill Creek Bioassessment Study Sampling Stations for the Fall 2008 Sampling Season

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Mill Creek #1	0804093	65	9	6.60	2.62	14	P
Mill Creek #2	0804092	60	12	6.90	2.70	14	P
Big Creek #1	0804094	76	15	6.60	3.25	20	F
Sugar Creek	0804095	67	10	6.60	2.97	20	F
Grassy Creek #1	0804099	67	12	6.30	2.73	18	F
Brush Creek #1	0804098	66	10	6.60	3.00	18	F
Hays Creek #1a	0804096	67	9	7.00	2.79	16	F
Hays Creek #1b	0804097	57	8	6.9	2.54	12	P
Metric Score=5	If	>66	>9	<6.83	>2.75	20-16	Full
Metric Score=3	If	66-33	9-5	6.83-8.41	2.75-1.37	14-10	Partial
Metric Score=1	If	<33	<5	>8.10	<1.37	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=5); TR=taxa richness;  
 EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

### 3.3.2 Macroinvertebrate Percent and Community Composition

The percent composition of EPTT, Ephemeroptera, Plecoptera, Trichoptera, functional feeding groups (FFG), functional habitat groups (FHG), and the five dominant macroinvertebrate families and taxa at each station are presented in Tables 10 through 13. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

Samples collected at the Mill Creek test stations had a much higher percentage of EPT taxa than the small regional reference streams during the spring 2008 sampling season (Table 10). The perlodid stonefly *Isoperla* was very abundant in the Mill Creek samples and accounted for much of the EPT percentage. Gatherer-collectors were the most abundant FFG during the spring sampling season in the samples from the Mill Creek test stations and the small candidate reference streams. Predators and scrapers were also very abundant at most of the sampling stations. The predator values were generally higher and scrapers lower at the Mill Creek test

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stations compared to the samples from the small candidate reference streams. Filterers and shredders were low in abundance at the sampling stations, except at Sugar Creek for filterers and at Brush Creek for shredders. Sprawlers were the most abundant FHG at the Mill Creek test stations and at most of the small candidate reference streams during the spring sampling season. Clingers were the second most abundant FHG at the Mill Creek test stations and at most of the small candidate reference streams. The other categories of FHG were generally low, except burrowers and climbers at Big Creek.

The perlodid stonefly *Isoperla* and the chironomid *Hydrobaenus* were the two most abundant taxa at the Mill Creek test stations and at most of the Central Plains/Cuivre/Salt EDU small candidate reference streams during the spring 2008 sampling season (Table 11). Big Creek #1 and Brush Creek #1 were the only sampling stations in which *Isoperla* was not very abundant. *Hydrobaenus* was much more abundant at Big Creek than the other sampling stations and the only station where *Caenis latipennis* was fairly abundant. The amphipod *Crangonyx* was abundant at all of the sampling stations and made up at least 20 percent of the sample at Sugar Creek and Grassy Creek. The isopod *Caecidotea* was abundant at Mill Creek test station #1 with values much higher than the other sampling stations. Other taxa that had high abundances at one or more of the sampling stations was the black fly *Prosimulium* at Sugar Creek #1, the oligochaete worm Enchytraeidae at Brush Creek #1, the orthoclad chironomid *Eukiefferiella* at Grassy, Brush, and Hays creeks, the orthoclad chironomid *Tvetenia* at Grassy Creek, the orthoclad chironomid group *Cricotopus/Orthocladius* at Brush Creek, and the orthoclad chironomid *Parametriocnemus* at Hays Creek.

The percent EPT of the samples from the fall 2008 sampling season collected at the Mill Creek test stations was lower than the values found in the samples collected at the small candidate reference streams (Table 12). Mayfly taxa from the families Baetidae, Caenidae, and Heptageniidae accounted for most of the EPT percentage in the samples (Table 13). The gatherer-collectors were the most abundant FFG in the Mill Creek and small candidate reference stream samples during the fall sampling season (Table 12). Other FFG that were abundant were the filterers and scrapers with each FFG accounting for about 15 to 30 percent of the samples. Shredders were also somewhat abundant in the samples, ranging from 4.00 percent at Mill Creek #2 to 12.96 percent at Big Creek. Clingers were the most abundant FHG in all of the samples, ranging from 31.53 at Hays Creek #1a to 54.47 at Sugar Creek #1. Other FHG that were abundant were the climbers and sprawlers. Swimmers were also abundant in some samples, ranging from 1.96 percent at Hays Creek #1b to 9.59 percent at Mill Creek #2.

The black fly *Simulium*, the isopod *Caecidotea*, and the mayfly *Caenis latipennis* were abundant at the Mill Creek test stations during the fall 2008 sampling season (Table 13). Other taxa that were abundant were the orthoclad chironomid group *Cricotopus/Orthocladius*, the heptageniid mayfly *Stenonema femoratum* at Mill Creek #1, the tanytarsini chironomid *Tanytarsus*, and the baetid mayfly *Baetis* at Mill Creek #2. *Simulium* and *Caenis latipennis* were abundant at all of the Central Plains/Cuivre/Salt EDU small candidate reference streams, but unlike the Mill Creek test stations, *Caecidotea* was in low abundance except at Sugar Creek. Other taxa that had high abundances in the Central Plains/Cuivre/Salt EDU small candidate reference streams at all or

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most of sampling stations were *Stenonema femoratum*, *Tanytarsus*, and the hydropsychid caddisfly *Cheumatopsyche*. Other taxa that had high abundance at one or more of the Central Plains/Cuivre/Salt EDU small candidate reference streams included the orthoclad chironomid *Cricotopus bicintus* at Big Creek, *Baetis* at Grassy Creek and Brush Creek, and the chironomini chironomid *Polypedilum convictum* in the two Hays Creek samples.

### **3.3.3 Biological Assessment QA/QC**

Duplicate macroinvertebrate samples were collected at Hays Creek #1 during the fall 2008 sampling season and Big Creek #1 during the spring 2009 sampling season. The quantitative similarity index for taxa (QSIT) was used to determine the percent similarity of the duplicate samples. The QSIT compares two macroinvertebrate samples by looking at the presence or absence of taxa and relative abundance (percent composition) of the taxa present (MDNR 2003b). Duplicate samples that were collected in a similar manner should have at least 70% taxa similarity (Rabeni et al. 1999, MDNR 2003b). The QSIT for the duplicate samples collected at Hays Creek #1 was 86.2 during the fall 2008 sampling season and 82.6 for duplicate samples collected at Big Creek #1 during the spring 2009 sampling season.

Table 10  
Biological Metric Values for EPT, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Mill Creek Study Sampling Stations, Spring 2008

Variable-Station	Mean Biocriteria Reference	Mill Ck. #1	Mill Ck. #2	Big Ck. #1	Sugar Ck. #1	Grassy Ck. #1	Brush Ck. #1	Hays Ck. #1
Sample Number	-	0804144	0804145	0804142	0804143	0804146	0804147	0804148
Sample Date	-	04/02/08	04/02/08	04/02/08	04/02/08	04/03/08	04/03/08	04/03/08
<b>EPT Metrics</b>								
% EPT	26.49	46.32	55.51	13.03	27.37	34.01	14.80	26.18
% Ephemeroptera	20.88	0.55	0.11	8.06	0	0	4.41	0.61
% Plecoptera	2.51	40.24	53.18	4.07	26.28	33.94	8.57	25.19
% Trichoptera	3.10	5.53	2.22	0.45	1.09	0.07	1.82	0.38
<b>FFG Metrics</b>								
% Filterers	13.96	2.62	1.46	2.08	12.83	0.35	1.59	1.75
% Gatherer	45.11	52.40	51.64	50.68	44.71	60.77	51.97	54.24
Collectors								
% Parasites	0.48	0.05	-	0.51	0.05	-	0.15	0.04
% Piercers	3.80	0.14	0.06	0.10	0.15	0.04	0.20	0.04
% Predators	8.93	24.37	30.70	4.66	15.84	20.64	7.27	14.32
% Scrapers	13.53	16.43	14.39	32.84	24.92	16.33	24.46	26.55
% Shredders	11.20	3.49	1.64	7.40	1.14	1.61	13.35	2.36
<b>FHG Metrics</b>								
% Burrowers	11.21	2.57	2.38	13.93	1.19	1.78	19.16	2.75
% Clingers	46.53	37.51	38.18	11.01	38.73	26.75	24.72	24.90
% Climbers	18.50	0.44	0.07	8.26	0.06	0.05	3.88	0.54
% Divers	0.39	0.05	0.07	0.24	0.20	0.05	0.06	-
% Skaters	0.06	-	-	-	-	-	-	-
% Sprawlers	16.33	40.69	48.51	54.44	36.88	50.63	37.86	58.57
% Swimmers	4.92	0.33	0.14	0.24	0.26	0.10	0.52	-

Table 11  
 Dominant Macroinvertebrate Families and Taxa at the Sampling Stations of the Mill Creek Bioassessment Study during the Spring 2008 Sampling Season

Variable-Station	Mill Ck. #1	Mill Ck. #2	Big Ck. #1	Sugar Ck. #1	Grassy Ck. #1	Brush Ck. #1	Hays Ck. #1
<b>Percent Dominant Families</b>							
Periodidae	<b>37.71</b>	<b>52.22</b>	1.72	<b>25.10</b>	<b>32.04</b>	<b>3.90</b>	<b>22.75</b>
Chironomidae	<b>21.42</b>	<b>23.31</b>	<b>65.76</b>	<b>21.49</b>	<b>36.90</b>	<b>62.86</b>	<b>52.74</b>
Asellidae	<b>12.41</b>	1.91	0	<b>2.43</b>	0.77	0.35	1.07
Crangonyctidae	<b>8.85</b>	<b>11.33</b>	<b>5.43</b>	<b>23.76</b>	<b>22.18</b>	<b>6.58</b>	<b>9.28</b>
Simuliidae	<b>3.87</b>	<b>2.44</b>	1.09	<b>21.66</b>	0.56	1.73	<b>2.43</b>
Enchytraeidae	1.26	<b>2.65</b>	<b>2.26</b>	0.50	<b>3.45</b>	<b>8.48</b>	<b>3.65</b>
Caenidae	0.32	0	<b>7.70</b>	0	0	<b>4.07</b>	0.61
Tubificidae	2.13	0.10	<b>2.90</b>	0.67	<b>1.06</b>	0.35	1.60
<b>Percent Dominant Taxa</b>							
<i>Isoperla</i>	<b>37.71</b>	<b>52.22</b>	1.72	<b>25.10</b>	<b>32.04</b>	3.90	<b>22.75</b>
<i>Hydrobaenuss</i>	<b>17.08</b>	<b>21.19</b>	<b>46.38</b>	<b>19.14</b>	<b>13.66</b>	<b>11.26</b>	<b>26.03</b>
<i>Caecidotea</i>	<b>12.33</b>	1.91	0	<b>2.43</b>	0.14	0.35	1.07
<i>Crangonyx</i>	<b>8.85</b>	<b>11.12</b>	<b>5.43</b>	<b>23.76</b>	<b>21.90</b>	<b>6.58</b>	<b>9.28</b>
<i>Prosimilium</i>	<b>3.87</b>	<b>2.44</b>	1.09	<b>21.66</b>	0.56	0.95	2.44
Enchytraeidae	1.26	<b>2.65</b>	<b>2.26</b>	0.50	<b>3.45</b>	<b>8.48</b>	3.65
<i>Stictochironomus</i>	0	0.21	<b>8.42</b>	0	0	0.17	0.08
<i>Caenis latipennis</i>	0.32	0	<b>7.70</b>	0	0	4.07	0.61
<i>Eukiefferiella</i>	0.24	0.11	0	0.67	<b>10.77</b>	<b>17.74</b>	<b>15.60</b>
<i>Tvetenia</i>	0	0	0.91	0.08	<b>9.08</b>	0.78	1.60
<i>Cricotopus/Orthocladius</i>	3.00	1.69	2.08	0.50	1.48	<b>21.04</b>	2.28
<i>Parametriocnemus</i>	0	0	1.63	0	0	0	<b>4.95</b>

Values in bold indicate the five most abundant macroinvertebrate families and taxa for each sample.

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Table 12  
 Biological Metric Values for EPT, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Mill Creek Study Sampling Stations, Fall 2008

Variable-Station	Mean Biocriteria Reference	Mill Ck. #1	Mill Ck. #2	Big Ck. #1	Sugar Ck. #1	Grassy Ck. #1	Brush Ck. #1	Hays Ck. #1a	Hays Ck. #1b
Sample Number	-	0804093	0804092	0804094	0804095	0804099	0804098	0804096	0904097
Sample Date	-	09/29/08	09/29/08	09/29/08	09/30/08	10/01/08	09/30/08	09/30/08	09/30/08
<b>EPT Metrics</b>									
% EPT	37.54	22.87	24.80	35.63	37.62	36.23	43.74	49.26	55.18
% Ephemeroptera	22.78	21.12	20.03	29.70	23.85	29.55	30.90	41.19	47.58
% Plecoptera	0.01	0	0.17	0.44	0.17	0.08	0.50	0.28	0.15
% Trichoptera	14.75	1.75	4.60	5.48	13.60	6.60	12.38	7.79	7.44
<b>FFG Metrics</b>									
% Filterers	27.54	22.73	19.90	15.44	2.46	27.16	21.40	14.62	14.74
% Gatherer	37.54	45.81	53.40	44.45	26.32	39.68	43.52	46.71	45.24
Collectors									
% Parasites	0.46	0.10	0.91	0.09	41.25	0.37	0.10	0.08	0.09
% Piercers	3.44	1.43	1.09	1.91	2.11	1.54	1.34	0.78	0.48
% Predators	8.26	2.37	2.67	3.83	3.66	2.76	2.59	1.94	1.58
% Scrapers	12.41	18.98	17.29	19.88	17.22	23.55	20.87	26.89	29.09
% Shredders	6.90	7.74	4.00	12.96	6.98	4.40	7.63	6.80	7.37
<b>FHG Metrics</b>									
% Burrowers	4.27	5.76	6.28	7.46	5.47	2.46	3.90	3.28	2.44
% Clingers	46.53	38.01	33.51	41.51	54.47	47.65	39.91	31.53	32.28
% Climbers	18.50	18.28	11.62	24.94	12.40	20.48	25.81	32.62	34.58
% Divers	0.39	0.43	0.07	0.10	0.47	0.11	0.15	0.14	-
% Skaters	0.06	-	-	0.10	0.33	0.06	-	-	-
% Sprawlers	16.33	15.09	8.85	18.54	9.8	13.67	19.73	25.07	26.10
% Swimmers	4.92	2.03	9.59	4.63	5.73	8.64	6.90	1.73	1.96

Table 13  
 Dominant Macroinvertebrate Families and Taxa at the Sampling Stations of the Mill Creek Bioassessment Study during the Fall 2008 Sampling Season

Variable-Station	Mill Ck. #1	Mill Ck. #2	Big Ck. #1	Sugar Ck. #1	Grassy Ck. #1	Brush Ck. #1	Hays Ck. #1a	Hays Ck. #1b
<b>Percent Dominant Families</b>								
Simuliidae	<b>25.03</b>	<b>10.41</b>	<b>7.19</b>	<b>16.04</b>	<b>26.25</b>	<b>8.88</b>	3.30	<b>6.29</b>
Chironomidae	<b>19.93</b>	<b>24.63</b>	<b>47.19</b>	<b>28.38</b>	<b>25.20</b>	<b>39.71</b>	<b>33.05</b>	<b>31.01</b>
Asellidae	<b>19.37</b>	<b>32.18</b>	0	<b>7.81</b>	0.40	0.53	1.96	1.00
Caenidae	<b>15.94</b>	<b>5.90</b>	<b>17.55</b>	4.45	<b>14.57</b>	<b>17.92</b>	<b>31.86</b>	<b>36.07</b>
Heptageniidae	<b>3.63</b>	2.52	<b>6.22</b>	<b>13.10</b>	3.06	3.34	<b>7.09</b>	<b>8.37</b>
Baetidae	1.54	<b>11.62</b>	<b>5.85</b>	6.30	<b>11.84</b>	<b>9.57</b>	2.25	3.15
Hydropsychidae	1.47	4.42	4.81	<b>13.43</b>	<b>6.60</b>	<b>12.00</b>	<b>7.79</b>	<b>7.37</b>
Elmidae	3.29	0.22	5.33	1.09	0.72	0.99	<b>4.14</b>	2.30
<b>Percent Dominant Taxa</b>								
<i>Simulium</i>	<b>25.03</b>	<b>10.32</b>	<b>7.19</b>	<b>16.04</b>	<b>26.25</b>	<b>8.88</b>	3.30	<b>6.29</b>
<i>Caecidotea</i>	<b>19.37</b>	<b>32.18</b>	0	<b>7.72</b>	0.40	0.53	1.96	1.00
<i>Caenis latipennis</i>	<b>15.94</b>	<b>5.90</b>	<b>17.56</b>	4.45	<b>14.57</b>	<b>17.92</b>	<b>31.86</b>	<b>36.07</b>
<i>Cricotopus/Orthocladius</i> grp.	<b>5.34</b>	1.91	4.59	2.77	0.24	0.84	0.98	0.84
<i>Stenonema femoratum</i>	<b>3.57</b>	2.34	<b>6.00</b>	<b>12.68</b>	2.50	3.34	<b>6.95</b>	<b>8.37</b>
<i>Tanytarsus</i>	2.59	<b>5.72</b>	<b>7.41</b>	<b>6.47</b>	<b>7.17</b>	<b>9.64</b>	<b>9.26</b>	<b>8.67</b>
<i>Baetis</i>	1.54	<b>10.32</b>	3.85	5.71	<b>10.39</b>	<b>8.81</b>	2.04	3.07
<i>Cricotopus bicinctus</i>	0.63	0.95	<b>5.18</b>	2.52	0.24	0.30	0.70	0.54
<i>Cheumatopsyche</i>	1.47	4.42	4.81	<b>13.43</b>	<b>6.52</b>	<b>12.00</b>	<b>7.79</b>	<b>7.29</b>
<i>Polypedilum convictum</i>	3.22	0.95	5.11	2.85	1.61	3.11	<b>5.75</b>	<b>7.06</b>

Values in bold indicate the five most abundant macroinvertebrate families and taxa for each sample.

### **3.4 Physicochemical Water Sample Collection and Analysis**

Water samples and field measurements were collected during the spring and fall 2008 macroinvertebrate sampling periods. Physicochemical results are arranged to demonstrate trends of certain variables that may identify a source for impacts at the Mill Creek test stations and the small candidate reference streams. Results can be found in Table 14 for spring sampling season and Table 15 for the fall sampling season. Results shown here are for quality control, discharge, nitrate + nitrite-N, and total nitrogen by season.

#### **3.4.1 Quality Control**

Duplicate samples were collected at Hays Creek #1 during the fall 2008 sampling season. Results from these duplicates were similar and indicated that sampling, transport, processing, and analyses of samples were consistent as well as precise (Table 15).

#### **3.4.2 Discharge**

Discharge was much lower at Brush and Hays creeks than the other sampling stations during the spring sampling season (Table 14). Discharge during the sampling season ranged from 2.94 cfs at Hays Creek to 55.2 cfs at Big Creek.

Discharge was low at all of the sampling stations during the fall sampling season (Table 14). Discharge ranged from 1.19 cfs at Hays Creek to 2.89 cfs at Sugar Creek.

#### **3.4.3 Nitrate + Nitrite-N**

Nitrate + nitrite-N, during the spring sampling season, was elevated at all of the sampling stations compared to the recommended reference condition value for the Level III Interior River Valleys and Hills ecoregion (U.S. EPA 2000). Nitrate + nitrite-N ranged from 0.25 mg/L at Brush and Hays creeks to 1.92 mg/L at Sugar Creek (Table 13). The U.S. EPA calculated the reference condition for nitrate + nitrite-N at 0.22 mg/L in the Interior River Valleys and Hills ecoregion.

Nitrate + nitrite-N was not as elevated during the fall sampling season compared to the values collected during the spring sampling season, with only Sugar and Grassy creeks having values above the U.S. EPA recommended reference condition value. Nitrate + nitrite-N ranged from 0.02 mg/L at Big Creek to 0.84 mg/L at Grassy Creek (Table 14).

#### **3.4.4 Total Nitrogen**

Total nitrogen was higher than the recommended reference condition value for the Level III Interior River Valleys and Hills ecoregion at the two Mill Creek test stations and at the sampling stations at Sugar and Grassy creeks (U.S. EPA 2000). Total nitrogen ranged from 0.44 mg/L at Brush Creek to 2.23 mg/L at Sugar Creek (Table 14). The U.S. EPA calculated the reference condition for total nitrogen at 0.75 mg/L in the Interior River Valleys and Hills ecoregion. The data that U.S. EPA used to calculate the total nitrogen reference value did not come from reported total nitrogen values from samples, but instead was calculated from nitrate + nitrite-N and Total Kjeldahl Nitrogen (TKN) sample values. This was done since many of the samples

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collected in the Interior River Valleys and Hills ecoregion did not have reported total nitrogen values but had nitrate + nitrite-N and TKN values.

Total nitrogen values were much lower during the fall sampling season compared to the values collected during the spring sampling season, with only Grassy Creek having a value above the U.S. EPA recommended reference condition value. Total nitrogen ranged from 0.17 mg/L at Hays Creek #1a to 0.89 mg/L at Grassy Creek (Table 15).

Table 14  
Physicochemical Variables at the Mill Creek Bioassessment Study Sampling Stations  
Spring 2008

	Mill Creek #1	Mill Creek #2	Big Creek #1	Sugar Creek #1	Grassy Creek #1	Brush Creek #1	Hays Creek #1
Invertebrate Sample Number	0804144	0804145	0804142	0804143	0804146	0804147	0804148
Physicochemical Sample Number	0803586	0803587	0803584	0803585	0803588	0803589	0803590
Sample Date	04/02/08	04/02/08	04/02/08	04/02/08	04/03/08	04/03/09	04/03/08
Sample Time	1455	1650	1020	1250	0905	1105	1310
Ammonia	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*
Chloride	11.2	11.3	17.4	14.8	12.8	14.2	9.25
Dissolved Oxygen	9.73	9.20	10.7	10.3	12.5	14.6	12.0
Discharge (cfs)	27.5	18.7	55.2	25.6	10.4	3.08	2.94
pH (Units)	8.00	8.20	7.90	8.10	8.10	8.30	8.00
Conductivity (umhos/cm)	328	320	251	382	354	326	332
Temperature (°C)	10.5	10.5	6.50	9.00	7.00	7.50	7.50
Turbidity (NTU)	5.48	4.98	29.1	7.11	2.48	3.27	2.25
Nitrate + Nitrite	<b>1.01</b>	<b>1.01</b>	<b>0.24</b>	<b>1.92</b>	<b>1.88</b>	<b>0.25</b>	<b>0.25</b>
Total Nitrogen	<b>1.29</b>	<b>1.25</b>	0.72	<b>2.23</b>	<b>2.10</b>	0.44	0.48
Total Phosphorus	0.01*	0.01*	0.02**	0.02**	0.01*	0.01*	0.01*

\*Below detectable limits

\*\*Estimated value, detected below Practical Quantitation Limit

Units mg/L unless otherwise noted. Values in bold are elevated compared to U.S. EPA recommended reference condition values

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Table 15

Physicochemical Variables at the Mill Creek Bioassessment Study Sampling Stations, Fall 2008

	Mill Creek #1	Mill Creek #2	Big Creek #1	Sugar Creek #1	Grassy Creek #1	Brush Creek #1	Hays Creek #1a	Hays Creek #1b
Invertebrate Sample Number	0804093	0804092	0804094	0804095	0804099	0804098	0804096	0804097
Physicochemical Sample Number	0810039	0810038	0810040	0810041	0810045	0810044	0810042	0810043
Sample Date	09/29/08	09/29/08	09/29/08	09/30/08	10/01/08	09/30/08	09/30/08	09/30/08
Sample Time	1440	1110	1720	0910	1130	1635	1300	1300
Ammonia	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*
Chloride	12.2	13.9	15.9	12.9	10.6	9.80	5.20	5.25
Dissolved Oxygen	7.77	7.55	8.08	7.59	8.18	7.54	5.42	-
Discharge (cfs)	2.47	2.00	2.72	2.89	2.21	2.04	1.19	-
pH (Units)	7.75	7.56	7.88	7.74	7.66	7.86	7.46	-
Conductivity (umhos/cm)	472	451	445	554	471	402	440	-
Temperature (°C)	20.8	17.7	19.8	15.8	16.8	18.2	18.0	-
Turbidity (NTU)	1.00*	3.12	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Nitrate + Nitrite	0.06	0.12	0.02**	<b>0.55</b>	<b>0.84</b>	0.11	0.07	0.07
Total Nitrogen	0.18	0.30	0.14	0.63	<b>0.89</b>	0.23	0.17	0.20
Total Phosphorus	0.03**	0.05	0.04**	0.06	0.04**	0.04**	0.05**	0.04**

\*Below detectable limits

\*\*Estimated value, detected below Practical Quantitation Limit

Units mg/L unless otherwise noted. Values in bold are elevated compared to U.S. EPA recommended reference condition values

## 4.0 Discussion

The discussion describes possible effects of stream size, stream habitat, sedimentation, and physicochemical conditions on the MSCI scores and macroinvertebrate community composition.

### 4.1 Macroinvertebrate MSCI Scores

A comparison of the MSCI scores using the two sets of criteria, one from the perennial/wadeable stream biological criteria and the other calculated from the samples collected at the small candidate reference streams, indicated that the streams sampled in this study had a less diverse and less balanced macroinvertebrate community than the biological criteria reference streams (Tables 6 through 9). With the exception of Hays Creek (#0804148), all of the samples for this study during the spring 2008 sampling season had higher MSCI scores using the small candidate reference stream criteria compared to the perennial/wadeable stream biological criteria. This

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indicates that stream size had a strong influence on the macroinvertebrate community and the small candidate reference criteria should be used to assess impairment of the Mill Creek test stations.

With the exception of the spring 2008 Mill Creek #1 sample, the small candidate reference criteria MSCI scores at the Mill Creek test stations for both sampling seasons were in the partial supporting category with a score of 14. The spring 2008 Mill Creek #1 sample had a fully supporting category score of 16. These results indicate that Mill Creek had an impaired macroinvertebrate community that was slightly less diverse and balanced compared to the small candidate reference streams. The primary source of the impairment is unknown at this time since the stream habitat assessment, visual sediment estimate analysis, and most of the physicochemical variables were not elevated. The only physicochemical variables that were elevated were nitrate + nitrite-N and total nitrogen during the spring sampling season. These two nitrogen parameters were elevated at the Mill Creek test stations and two of the small candidate reference streams (Grassy and Sugar creeks) that scored in the partial supporting category (Table 14). The stream habitat assessment indicated that the Mill Creek test stations were not habitat limited compared to the small candidate reference streams (Table 3). The only stream habitat variables that had poor or somewhat poor values were vegetative protection and riparian zone width. The visual sediment estimate analysis showed that Mill Creek #2 had elevated levels of sediment compared to Mill Creek #1, but was not statistically different ( $p<0.05$ ) than the small candidate reference streams (Tables 4 and 5).

## 4.2 Functional Feeding and Functional Habitat Groups

Functional feeding groups (FFG) and functional habitat groups (FHG) have been used as an indicator of elevated levels of benthic sediment in some studies. Rabeni et al. (2005) classified FFG for sediment tolerance from intolerant to tolerant in the following order: filterers < scrapers < predators < gatherer-collectors < scrapers. Based on these results, filters and scrapers were considered sediment intolerant, predators slightly more tolerant than scrapers, and gatherer-collectors and scrapers sediment tolerant. Functional feeding group results during both sampling seasons showed that filterers were lower and gatherer-collectors and scrapers were generally higher in abundance at the Mill Creek and small candidate reference streams than the mean values for those groups at the biological criteria reference streams in the Central Plains/Cuivre/Salt EDU (Tables 10 and 12). Shredders were much lower in abundance during the spring sampling season at all of the sampling stations and slightly higher at half of the sampling stations during the fall sampling season compared to the biological criteria reference streams. Predator abundance was much higher during the spring sampling season than the fall sampling season. Spring predator abundance was also much higher at most sampling stations than the mean predator value for the biological criteria streams. The FFG results did not conclusively indicate that FFG was being impacted by benthic sediment since the filterer values were low, but gatherer-collector and scraper values were high compared to the biological criteria reference streams. There was no evidence that the significantly higher levels of benthic sediment ( $p<0.05$ ) at Mill Creek #2 as compared to Mill Creek #1 were greatly altering the FFG composition (Tables 10 and 12). It should be mentioned that it may be difficult to draw a correlation between benthic sediment and macroinvertebrates since macroinvertebrates may not

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be collected in the same locations within the stream reach where sediment estimations were made since macroinvertebrate collection and sediment estimation have very different sampling protocols.

Rabeni et al. (2005) classified FHG for sediment tolerance from intolerant to tolerant in the following order: clingers < swimmers < sprawlers < climbers < burrowers. Based on these results, clingers and swimmers were considered sediment intolerant, sprawlers slightly more intolerant than climbers, and burrowers and climbers sediment tolerant. Clingers were slightly lower in abundance at most of the sampling stations and swimmers were much lower at all of the sampling stations compared to the mean values from the biological criteria reference streams during the spring sampling season (Table 10). The abundance of burrowers was much lower at the sampling stations, except at Brush Creek #1, and climbers at all of the sampling stations compared to the biological criteria reference streams during the spring sampling season.

Sprawlers were much more abundant during the spring sampling season compared to the biological criteria reference streams. During the fall sampling season, clingers were lower at the sampling stations, except at Sugar Creek and Grassy Creek, than the mean value for the biological criteria reference streams. Swimmers showed no consistent trend with half of the samples having higher values and half having lower values compared to the biological criteria reference streams. Burrowers were slightly more abundant at the Mill Creek test stations, Big Creek #1, and Sugar Creek #1 and slightly lower at the other sampling stations during the fall sampling season than the mean value for the biological criteria streams. Climbers were lower in abundance at the Mill Creek test stations during the fall sampling season than most of the small candidate reference streams. Compared to the biological criteria mean value, climbers were slightly lower at Mill Creek #1 and much lower at Mill Creek #2. Sprawlers were much less abundant during the fall sampling season than the spring sampling season and were lower at most of the sampling stations than the biological criteria streams. Results of the FHG were inconclusive as they related to elevated benthic sediment levels since the intolerant clingers were lower during both sampling seasons and the tolerant burrowers were lower during the spring sampling season and only slightly higher during the fall sampling season at the Mill Creek test stations.

## 4.3 Dominant Macroinvertebrate Taxa

The results for the spring sampling season showed that the perlodid stonefly *Isoperla*, the orthoclad chironomid *Hydrobaenus*, and the amphipod *Crangonyx* were dominant in most of the samples (Table 11). Other taxa like the isopod *Caecidotea*, the black fly *Prosimulium*, enchytraeid oligochaete worms, orthoclad chironomids *Eukiefferiella*, *Tvetenia*, *Cricotopus/Orthocladius* group, and *Parametriocnemus* were abundant in at least one of the sampling stations. At the Mill Creek test stations, the three most abundant taxa made up a very large proportion of the samples. *Isoperla*, *Hydrobaenus*, and *Caecidotea* made up 67.1 percent of the sample at Mill Creek #1 whereas *Isoperla*, *Hydrobaenus*, and *Crangonyx* made up 84.5 percent of the sample at Mill Creek #2. The five most abundant taxa made up 79.4 percent at Mill Creek #1 and 89.6 percent at Mill Creek #2. The dominance of just a few taxa for many of the samples resulted in low SDI values during the spring sampling season.

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The macroinvertebrate community during the fall sampling season was more diverse and was not dominated by just a few taxa compared to the spring sampling season. The black fly *Simulium*, the mayfly *Caenis latipennis*, the caddisfly *Cheumatopsyche*, and the tanytarsini chironomid *Tanytarsus* were abundant in most of the sampling stations (Table 13). Other taxa that were common in some of the samples were the isopod *Caecidotea*, the heptageniid mayfly *Stenonema femoratum*, and the baetid mayfly *Baetis*. At both Mill Creek test stations, *Simulium*, *Caecidotea*, and *Caenis latipennis* were abundant. Other taxa that were common at Mill Creek were the *Cricotopus/Orthocladius* group and *Stenonema femoratum* at Mill Creek #1 and *Tanytarsus* and *Baetis* at Mill Creek #2. The three most abundant taxa at Mill Creek #1 made up 60.3 percent and at Mill Creek #2 made up 52.8 percent. The five most abundant taxa made up 69.3 percent at Mill Creek #1 and 64.4 percent at Mill Creek #2.

## 5.0 Conclusions

The macroinvertebrate MSCI scores indicated impairment at the Mill Creek test stations using both the biological criteria from the biological reference streams and the small candidate reference stream criteria. All four Mill Creek samples scored in the partial or non-supporting category using biological criteria from the reference streams and three out of four samples using the criteria from the small candidate reference streams. Based on the results of this study, the criteria calculated from the small candidate reference streams should be used to assess Mill Creek since all of the sampling stations in the study had a macroinvertebrate community that was less diverse and balanced than the biological criteria streams. All of the Mill Creek samples collected during this study scored in the partial supporting category with a score of 14 using the small candidate reference stream criteria, except the Mill Creek #1 sample during the spring sampling season (score of 16).

The results from the MSCI scores using the small candidate reference stream criteria caused the first three null hypotheses to be rejected. The first three null hypotheses stated: 1) The macroinvertebrate community will not differ between longitudinally separate reaches of Mill Creek; 2) The macroinvertebrate community in Mill Creek will not differ from data collected from the riffle/pool biological criteria reference streams in the Central Plains/Cuivre/Salt EDU; 3) The macroinvertebrate community in Mill Creek will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU. The first null hypothesis was rejected since there was difference in MSCI supporting categories at the Mill Creek test stations during the spring sampling season. The second null hypothesis was rejected since all of the samples collected at the Mill Creek test stations had MSCI scores either in the non or partial supporting category using the biological criteria for the biological criteria reference streams. The third null hypothesis was rejected since all of the samples, except Mill Creek #1 during the spring sampling season, scored in the partial supporting category using the small candidate reference stream criteria.

There was no evidence that stream habitat was causing impairment at the Mill Creek test stations. The Mill Creek test stations had higher stream habitat assessment scores than the average stream habitat scores from the five small candidate reference streams. The only stream habitat categories that scored in the marginal or poor category at the Mill Creek test stations were

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vegetative protection and riparian zone width at Mill Creek #1 and vegetative protection at Mill Creek #2. These results allowed null hypotheses four and five to be accepted. Null hypotheses four and five stated: 4) The stream habitat scores will not differ among longitudinally separate reaches of Mill Creek and 5) The stream habitat assessment scores will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU.

The results from the visual estimate of benthic sediment did not indicate impairment at the Mill Creek test stations. These results showed that Mill Creek #1 had a significantly lower percentage of benthic sediment covering the stream bottom than Mill Creek #2 and two of the small candidate reference streams, Brush Creek and Grassy Creek. Mill Creek #2 had much more benthic sediment covering the stream bottom than Mill Creek #1 but was not significantly different than the sediment levels found at any of the small candidate reference streams, however, the visual estimate of benthic sediment results did cause the last two null hypotheses to be rejected. The last two hypotheses stated: 6) The visual estimates of the percentage of fine sediment covering the stream bottom in Mill Creek will not differ among longitudinally separate reaches of Mill Creek and 7) The visual estimates of the percentage of fine sediment covering the stream bottom in Mill Creek will not differ from the five small candidate reference streams in the Central Plains/Cuivre/Salt EDU. The sixth null hypothesis was rejected since the estimated percentage of benthic sediment was significantly different ( $p<0.05$ ) at the two Mill Creek test stations. The seventh hypothesis was rejected since Mill Creek #1 had significantly lower amounts of benthic sediment ( $p<0.05$ ) than two of the small candidate reference streams.

There was some evidence of nutrient enrichment, especially during the spring sampling season, at the Mill Creek test stations and two of the small candidate reference streams, Grassy and Sugar creeks. These sampling stations had much higher levels of nitrate + nitrite-N and total nitrogen than the U.S. EPA recommended reference condition values during the spring sampling seasons. The Mill Creek test stations did not have elevated nutrient levels during the fall sampling season, but nitrate + nitrite-N and total nitrogen were slightly elevated at Grassy Creek and nitrate + nitrite-N was elevated at Sugar Creek. All of the sampling stations that had elevated levels of total nitrogen during the spring sampling season, except Mill Creek #1, had MSCI scores in the partial supporting category. This result gave some evidence that the elevated nitrogen levels may have had at least some effect on the macroinvertebrate community and the MSCI scores during the spring sampling season.

The primary source of impairment at the Mill Creek test stations is not known at this time. There is no evidence to suggest that stream habitat, benthic sediment, and most of the physicochemical water quality parameters resulted in impairment. Of the factors considered in this study, only the elevated nitrate + nitrite-N and total nitrogen levels during the spring sampling season were observed as a possible source of impairment..

## **6.0 Recommendations**

1. More water quality monitoring is needed to determine possible sources of impairment at Mill Creek.

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Submitted by:

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## **Appendix A**

Statistical Analyses Comparing Benthic Sediment Estimates Between Sampling Stations. Kruskal-Wallis ANOVA on Ranks and Dunn's Multiple Comparison Test were used to Test Differences in the Percent of the Stream Bottom Covered by Benthic Sediment Between the Sampling Stations

**One Way Analysis of Variance**

Monday, November 30, 2009, 9:54:14 AM

**Data source:** Visual Estimate of Benthic Sediment

Dependent Variable: % Sediment

**Normality Test:** Failed (P < 0.050)

Test execution ended by user request, ANOVA on Ranks begun

**Kruskal-Wallis One Way Analysis of Variance on Ranks** Monday, November 30, 2009, 9:54:14 AM**Data source:** Data 1 in visual sediment.SNB

Group	N	Missing	Median	25%	75%
Mill Creek #1	18	0	5.000	1.000	17.500
Mill Creek #2	18	0	77.000	5.000	96.500
Big Creek #1	18	0	40.000	2.500	67.500
Sugar Creek #1	18	0	4.500	1.000	32.500
Hays Creek #1	18	0	17.500	10.000	87.500
Brush Creek #1	18	0	97.250	57.500	100.000
Grassy Creek #1	18	0	66.250	42.500	90.000

H = 32.228 with 6 degrees of freedom. (P = &lt;0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference. (P = &lt;0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
Brush Creek # vs Mill Creek #1	56.917	4.676	Yes
Brush Creek # vs Sugar Creek #	51.444	4.226	Yes
Brush Creek #1 vs Big Creek #1	38.139	3.133	Yes
Brush Creek # vs Hays Creek #1	29.944	2.460	No
Brush Creek # vs Mill Creek #2	19.722	1.620	Do Not Test
Brush Creek # vs Grassy Creek	18.694	1.536	Do Not Test
Grassy Creek vs Mill Creek #1	38.222	3.140	Yes
Grassy Creek vs Sugar Creek #	32.750	2.691	No
Grassy Creek vs Big Creek #1	19.444	1.597	Do Not Test
Grassy Creek vs Hays Creek #1	11.250	0.924	Do Not Test
Grassy Creek vs Mill Creek #2	1.028	0.0844	Do Not Test
Mill Creek #2 vs Mill Creek #1	37.194	3.056	Yes
Mill Creek #2 vs Sugar Creek #	31.722	2.606	Do Not Test
Mill Creek #2 vs Big Creek #1	18.417	1.513	Do Not Test
Mill Creek #2 vs Hays Creek #1	10.222	0.840	Do Not Test
Hays Creek #1 vs Mill Creek #1	26.972	2.216	No
Hays Creek #1 vs Sugar Creek #	21.500	1.766	Do Not Test
Hays Creek #1 vs Big Creek #1	8.194	0.673	Do Not Test
Big Creek #1 vs Mill Creek #1	18.778	1.543	Do Not Test
Big Creek #1 vs Sugar Creek #1	13.306	1.093	Do Not Test
Sugar Creek # vs Mill Creek #1	5.472	0.450	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

## **Appendix B**

Statistical Analyses Comparing Benthic Sediment Estimates Between Sampling Stations. Kruskal-Wallis ANOVA on Ranks and Dunn's Multiple Comparison Test were used to Test Differences in the Percent of the Stream Bottom Covered by Benthic Sediment Between the Mill Creek Test Stations and a Control Group Containing Data from the Small Regional Reference Streams

## One Way Analysis of Variance

Monday, November 30, 2009, 10:03:12 AM

**Data source:** Visual Estimate of Benthic Sediment, Data from Small Regional Reference Streams Combined into a Control Group to Compare with the Mill Creek Test Stations

Dependent Variable: % Sediment

**Normality Test:** Failed (P < 0.050)

Test execution ended by user request, ANOVA on Ranks begun

## Kruskal-Wallis One Way Analysis of Variance on Ranks

Monday, November 30, 2009, 10:03:12 AM

**Data source:** Data 1 in visual sediment.SNB

Group	N	Missing	Median	25%	75%
Mill Creek #1	18	0	5.000	1.000	17.500
Mill Creek #2	18	0	77.000	5.000	96.500
Control	90	0	42.500	6.500	90.000

H = 11.568 with 2 degrees of freedom. (P = 0.003)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference. (P = 0.003)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
Mill Creek #1 vs Control	29.272	3.105	Yes
Mill Creek #2 vs Control	7.922	0.840	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.

## **Appendix C**

Mill Creek Bioassessment Study Macroinvertebrate Bench Sheets

**Aquid Invertebrate Database Bench Sheet Report**  
**Big Cr [0804142], Station #1, Sample Date: 4/2/2008 10:45:00 AM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
<b>"HYDRACARINA"</b>			
Acarina	6	4	
<b>AMPHIPODA</b>			
Crangonyx	6	7	47
Hyalella azteca		1	1
<b>COLEOPTERA</b>			
Berosus		1	1
Helichus basalis	1		1
Paracymus		2	3
Scirtidae			1
Stenelmis	13	1	1
<b>DECAPODA</b>			
Orconectes virilis	1		3
<b>DIPTERA</b>			
Aedes		1	
Caloparyphus		1	
Ceratopogoninae	5	12	2
Chaoborus	4	5	
Chironomidae	2	1	
Chironomus	1	7	
Cladotanytarsus	2	1	
Clinocera	12	2	
Corynoneura			1
Cricotopus/Orthocladius	11	2	10
Cryptochironomus		1	
Cryptotendipes		1	
Dicrotendipes		2	
Diptera		2	1
Glyptotendipes		7	
Gonomyia		2	
Heterotrissocladius		1	
Hexatoma	1	2	1
Hydrobaenus	333	78	101
Microtendipes	1		
Myxosargus		1	
Nanocladius	1		
Ormosia			1
Orthocladius (Euorthocladius)	1		
Parametriocnemus	8	9	1
Paratanytarsus	3		4
Paratendipes	2	2	
Phaenopsectra	1	1	
Polypedilum halterale grp	1	1	
Procladius	1	1	
Prosimulium	12		
Pseudochironomus		1	1
Pseudorthocladius	1		
Rheocricotopus	1		1
Sictochironomus	13	79	1

**Aquid Invertebrate Database Bench Sheet Report**  
**Big Cr [0804142], Station #1, Sample Date: 4/2/2008 10:45:00 AM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Sympothastia	5	1	
Tanytarsus	6		5
Thienemanniella	1		
Tipula	-99		
Tvetenia	8		2
<b>EPHEMEROPTERA</b>			
Caenis latipennis	31	19	35
Stenonema femoratum	3	1	
<b>LIMNOPHILA</b>			
Fossaria	3		1
Physella	1		1
Planorbidae	1		
<b>ODONATA</b>			
Enallagma			2
<b>PLECOPTERA</b>			
Allocapnia	3		
Alloperla	5		
Amphinemura	1		3
Isoperla	13		6
Perlesta	13		1
<b>RHYNCHOBELLIDA</b>			
Glossiphoniidae	1		1
<b>TRICHOPTERA</b>			
Cheumatopsyche			-99
Limnephilidae			2
Oecetis		1	
Polycentropodidae	1		
Pycnopsyche	1		
<b>TUBIFICIDA</b>			
Aulodrilus		1	
Branchiura sowerbyi		3	
Enchytraeidae	12	10	3
Limnodrilus hoffmeisteri	2	2	
Tubificidae	20	4	
<b>VENEROIDA</b>			
Pisidiidae	2	1	

**Aquid Invertebrate Database Bench Sheet Report**

Sugar Cr [0804143], Station #1, Sample Date: 4/2/2008 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
"HYDRACARINA"			
Acarina	1		
AMPHIPODA			
Crangonyx	38	43	202
COLEOPTERA			
Heterosternuta		2	1
DIPTERA			
Caloparyphus	2		
Ceratopogoninae		2	
Chaoborus		1	
Chironomidae		4	1
Clinocera	1	1	
Cricotopus/Orthocladius	6		
Eukiefferiella	7		1
Glyptotendipes		1	
Hexatoma	2		
Hydrobaenus	15	212	1
Orthocladius (Euorthocladius)	1		
Paratendipes		1	
Prosimulium	234		24
Rheocricotopus		2	3
Silvius	-99		
Tvetenia	1		
HEMIPTERA			
Trichocorixa		1	
ISOPODA			
Caecidotea	8	2	19
LIMNOPHILA			
Physella		-99	
LUMBRICINA			
Lumbricina	-99	-99	
MESOGASTROPODA			
Hydrobiidae		1	
PLECOPTERA			
Amphinemura	7		2
Isoperla	286	3	10
Zealeuctra	5		
TRICHOPTERA			
Agapetus	2		
Iroquoia			2
Neophylax	2		
Polycentropodidae			1
Rhyacophila	6		
TRICLADIDA			
Planariidae	10		
TUBIFICIDA			
Enchytraeidae	3	3	
Limnodrilus hoffmeisteri			1

**Aquid Invertebrate Database Bench Sheet Report**

**Sugar Cr [0804143], Station #1, Sample Date: 4/2/2008 1:15:00 PM**

**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Tubificidae	1	6	

**Aquid Invertebrate Database Bench Sheet Report**

Mill Cr [0804144], Station #1, Sample Date: 4/2/2008 3:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
<b>"HYDRACARINA"</b>			
Acarina	1		
<b>AMPHIPODA</b>			
Crangonyx	2	22	88
Gammarus			2
<b>ARHYNCHOBELLIDA</b>			
Erpobdellidae		-99	
<b>COLEOPTERA</b>			
Agabus			-99
Helichus basalis			1
Heterosternuta			1
Neoporus		3	2
Peltodytes		1	
Stenelmis	9		
<b>DECAPODA</b>			
Orconectes luteus			-99
Orconectes virilis			1
<b>DIPTERA</b>			
Ceratopogoninae		3	
Chironomidae	2	1	
Clinocera	6	1	
Corynoneura			2
Cricotopus/Orthocladius	4	24	10
Diplocladius			1
Diptera			2
Eukiefferiella	2		1
Hydrobaenus		200	16
Microtendipes		1	
Odontomyia	1		
Orthocladius (Euorthocladius)	3		
Prosimulium	44		5
Pseudosmittia	1		
Rheocricotopus			1
Sympothastia		1	
Tanytarsus	1		
Tipula			-99
<b>EPHEMEROPTERA</b>			
Baetis			3
Caenis latipennis		3	1
<b>ISOPODA</b>			
Caecidotea	13	19	124
Caecidotea (Blind & Unpigmented)		1	
<b>LEPIDOPTERA</b>			
Crambidae			1
<b>LIMNOPHILA</b>			
Helisoma			-99
Physella	1		2
<b>MESOGASTROPODA</b>			

**Aquid Invertebrate Database Bench Sheet Report**  
**Mill Cr [0804144], Station #1, Sample Date: 4/2/2008 3:15:00 PM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Hydrobiidae		1	1
<b>PLECOPTERA</b>			
Amphinemura	32		
Isoperla	439		38
<b>TRICHOPTERA</b>			
Agapetus	24		3
Iroquoia			2
Ptilostomis		1	
Rhyacophila	33	2	5
<b>TRICLADIDA</b>			
Planariidae			1
<b>TUBIFICIDA</b>			
Aulodrilus		1	
Enchytraeidae	7	5	4
Ilyodrilus templetoni	1		
Limnodrilus hoffmeisteri		2	
Tubificidae	2	21	
<b>VENEROIDA</b>			
Pisidiidae	3	2	1

**Aquid Invertebrate Database Bench Sheet Report**

Mill Cr [0804145], Station #2, Sample Date: 4/2/2008 5:15:00 PM

CS = Coarse; NF = Nonflow; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>
AMPHIPODA		
Bactrurus		2
Crangonyx	14	91
COLEOPTERA		
Heterosternuta		1
DIPTERA		
Caloparyphus	1	1
Ceratopogoninae		3
Chironomidae	1	
Clinocera	1	
Cricotopus/Orthocladius	15	1
Diptera		1
Dolichopodidae	8	
Eukiefferiella	1	
Hydrobaenus	7	193
Ormosia		2
Pilaria		3
Prosimulium	23	
Stictochironomus		2
Tabanus	-99	
Tipula	-99	
EPHEMEROPTERA		
Siphlonurus		1
GORDIOIDEA		
Gordiidae		-99
ISOPODA		
Caecidotea	12	6
LIMNOPHILA		
Physella		1
PLECOPTERA		
Amphinemura	9	
Isoperla	490	3
TRICHOPTERA		
Iroquoia		1
Neophylax	4	
Rhyacophila	15	1
TRICLADIDA		
Planariidae	2	
TUBIFICIDA		
Enchytraeidae	15	10
Limnodrilus hoffmeisteri		1
VENEROIDA		
Pisidiidae		2

**Aquid Invertebrate Database Bench Sheet Report**

Grassy Cr [0804146], Station #1, Sample Date: 4/3/2008 9:20:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
AMPHIPODA			
Bactrurus		4	
Crangonyx	29	47	235
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
COLEOPTERA			
Heterosternuta		1	
Paracymus		1	
Stenelmis	1		
Tropisternus			1
DIPTERA			
Ceratopogoninae		1	
Chrysops		2	
Clinocera	2		
Cricotopus/Orthocladius	14	6	1
Eukiefferiella	144		9
Hexatoma	-99		
Hydrobaenus		188	6
Natarsia		1	
Ormosia			1
Orthocladius (Euorthocladius)	5	1	1
Prosimulium	8		
Rheocricotopus		4	
Smittia		1	
Sympothastia	17		
Tabanus		-99	
Tvetenia	107	3	19
ISOPODA			
Caecidotea			2
Caecidotea (Blind & Unpigmented)		9	
LEPIDOPTERA			
Crambidae	-99		
LIMNOPHILA			
Physella	2		
PLECOPTERA			
Allocapnia	4		
Amphinemura	6		1
Isoperla	449		6
Perlesta	13		1
Zealeuctra		1	1
TRICHOPTERA			
Ironoquia			-99
Nectopsyche		1	
Rhyacophila	-99		
TUBIFICIDA			
Enchytraeidae	11	35	3
Tubificidae	2	13	

**Aquid Invertebrate Database Bench Sheet Report**

Brush Cr [0804147], Station #1, Sample Date: 4/3/2008 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
<b>"HYDRACARINA"</b>			
Acarina	2		1
<b>AMPHIPODA</b>			
Crangonyx	4	30	42
Hyalella azteca			7
<b>COLEOPTERA</b>			
Dubiraphia		1	1
Helichus basalis			1
Heterosternuta		1	
Hydraena			1
Neoporus		1	
Peltodytes		1	1
Scirtidae			3
Stenelmis	6		
Tropisternus			1
<b>DECAPODA</b>			
Orconectes virilis		1	
<b>DIPTERA</b>			
Allognosta		1	
Cardiocladius	3		
Ceratopogoninae	1	1	
Chironomidae	4	3	4
Chironomus		1	
Chrysops		3	
Cladotanytarsus		3	
Corynoneura			1
Cricotopus/Orthocladius	101	42	100
Cryptotendipes		1	
Diptera		3	
Dolichopodidae	-99	1	
Eukiefferiella	187	14	4
Glyptotendipes			1
Hexatoma	7	-99	
Hydrobaenus	32	69	29
Limnophyes	1		
Mesosmittia		1	
Natarsia	4	15	3
Ormosia		2	
Orthocladius (Euorthocladius)	9		6
Paratanytarsus		1	
Pericoma		2	
Prosimulium	11		
Pseudosmittia	1		
Stegopterna	9		
Stictochironomus		2	
Sympothastia	50	5	18
Tabanus	1		
Tanytarsus		1	

**Aquid Invertebrate Database Bench Sheet Report**

Brush Cr [0804147], Station #1, Sample Date: 4/3/2008 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Thienemannimyia grp.			1
Tipula	-99		
Tvetenia	9		
EPHEMEROPTERA			
Ameletidae			2
Caenis latipennis		21	26
Leptophlebiidae			2
Stenonema femoratum		-99	
ISOPODA			
Caecidotea		1	3
LUMBRICINA			
Lumbricina		1	
ODONATA			
Enallagma			2
Gomphidae		1	
Ischnura			1
PLECOPTERA			
Amphinemura	8		
Isoperla	45		
Perlesta	34		3
Perlinella drymo		1	-99
Zealeuctra	4	4	
TRICHOPTERA			
Ironoquia			10
Rhyacophila	3		
Triaenodes			1
Wormaldia	7		
TUBIFICIDA			
Enchytraeidae	41	49	8
Limnodrilus hoffmeisteri		2	
Tubificidae		2	

**Aquid Invertebrate Database Bench Sheet Report**

Hays Cr [0804148], Station #1, Sample Date: 4/3/2008 1:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
AMPHIPODA			
Bactrurus	-99	-99	
Crangonyx	10	6	106
ARHYNCHOBDELLIDA			
Erpobdellidae		1	
COLEOPTERA			
Neoporus		1	1
Paracymus	1		
Psephenus herricki		1	
Stenelmis	7	1	
DECAPODA			
Orconectes virilis	-99	-99	-99
DIPTERA			
Ceratopogoninae	1		
Chironomidae		1	3
Clinocera	9	1	
Corynoneura			2
Cricotopus/Orthocladius	9	3	18
Cryptotendipes		1	
Diplocladius			2
Diptera		1	
Eukiefferiella	195	1	9
Hexatoma	1		1
Hydrobaenus		232	110
Mesosmittia		3	
Ormosia		2	
Orthocladius (Euorthocladius)	5		
Parametriocnemus	23	41	1
Paraphaenocladius			1
Prosimulium	32		
Rheocricotopus	1		4
Stictochironomus		1	
Sympothastia	4		
Tabanus	-99		
Tanytarsus		1	
Tvetenia	18		3
Zavrelimyia			1
EPHEMEROPTERA			
Caenis latipennis		3	5
ISOPODA			
Caecidotea	-99	-99	14
LIMNOPHILA			
Fossaria		1	1
Physella	-99	4	
PLECOPTERA			
Allocapnia	1		
Amphinemura	15		1
Isoperla	295	1	3

**Aquid Invertebrate Database Bench Sheet Report**  
**Hays Cr [0804148], Station #1, Sample Date: 4/3/2008 1:30:00 PM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Perlesta	15		
TRICHOPTERA			
Iroquoia			1
Polycentropodidae	1		
Polycentropus		1	
Ptilostomis			-99
Rhyacophila	2		
TUBIFICIDA			
Branchiura sowerbyi		9	
Enchytraeidae	2	46	
Limnodrilus claparedianus		1	
Tubificidae		11	
VENEROIDA			
Pisidiidae	2	3	

**Aquid Invertebrate Database Bench Sheet Report**

Mill Cr [0804092], Station #2, Sample Date: 9/29/2008 12:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
"HYDRACARINA"			
Acarina		2	13
AMPHIPODA			
Gammarus	2	2	2
COLEOPTERA			
Peltodytes			4
Stenelmis	3		
DECAPODA			
Orconectes virilis			1
DIPTERA			
Ablabesmyia		1	1
Aedes		1	
Ceratopogoninae		1	
Chironomidae		3	4
Chironomus		3	1
Cladotanytarsus		1	
Cnephia	1		
Corynoneura	1	4	2
Cricotopus bicinctus	1	2	8
Cricotopus/Orthocladius		6	16
Dicrotendipes		24	24
Eukiefferiella	15	1	1
Hexatoma	-99		
Hydrobaenus			1
Labrundinia			1
Micropsectra			9
Microtendipes		24	8
Parametriocnemus	2		
Paratanytarsus		3	6
Paratendipes		2	
Phaenopsectra		1	2
Polypedilum aviceps	4		
Polypedilum convictum	10		1
Polypedilum illinoense grp	2		
Pseudochironomus		1	
Rheotanytarsus	1	2	2
Simulium	115	3	1
Stempellinella		3	
Stictochironomus		3	1
Tanytarsus		33	33
Thienemannimyia grp.		1	
Tipulidae	2	1	
Tribelos		1	
Zavrelimyia		6	2
EPHEMEROPTERA			
Acerpenna	7		
Baetis	119		
Caenis latipennis		30	38

**Aquid Invertebrate Database Bench Sheet Report**

Mill Cr [0804092], Station #2, Sample Date: 9/29/2008 12:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Callibaetis			6
Centroptilum			1
Procloeon		1	
Stenacron			2
Stenonema femoratum	8	12	7
<b>HEMIPTERA</b>			
Belostoma			2
<b>ISOPODA</b>			
Caecidotea	184	132	55
<b>LIMNOPHILA</b>			
Lymnaeidae			10
Physella	1	3	29
<b>LUMBRICINA</b>			
Lumbricidae	1		
Lumbricina	1		
<b>ODONATA</b>			
Enallagma			5
<b>PLECOPTERA</b>			
Perlesta	2		
<b>TRICHOPTERA</b>			
Cheumatopsyche	50		1
Chimarra	1		
Nectopsyche			1
<b>TUBIFICIDA</b>			
Enchytraeidae		3	
<b>VENEROIDA</b>			
Pisidiidae		3	

**Aquid Invertebrate Database Bench Sheet Report**

Mill Cr [0804093], Station #1, Sample Date: 9/29/2008 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Crangonyx	2	2	19
Gammarus	-99	2	5
Hyalella azteca			3
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		-99
COLEOPTERA			
Berosus		1	1
Dubiraphia		3	2
Dytiscidae		3	
Ectopria nervosa	1		
Helichus lithophilus			2
Heterosternuta			3
Neoporus			2
Peltodytes		2	1
Stenelmis	36	4	2
DECAPODA			
Orconectes luteus	-99		
DIPTERA			
Ablabesmyia		6	1
Anopheles		1	2
Ceratopogoninae	1	2	
Chironomidae		1	
Chironomus			1
Cladotanytarsus		1	
Corynoneura			2
Cricotopus bicinctus	8		1
Cricotopus/Orthocladius	72		4
Cryptochironomus		3	
Dicrotendipes	3	7	4
Eukiefferiella	8		
Glyptotendipes		3	
Microtendipes		3	1
Parametriocnemus	3		
Paratanytarsus		3	7
Paratendipes			2
Phaenopsectra			2
Polypedilum convictum	45		1
Polypedilum halterale grp		2	
Polypedilum illinoense grp	5	1	3
Rheocricotopus	1		
Rheotanytarsus	16	1	1
Simulium	354		4
Stictochironomus		5	
Tabanus	-99		
Tanytarsus	2	31	4

**Aquid Invertebrate Database Bench Sheet Report**  
**Mill Cr [0804093], Station #1, Sample Date: 9/29/2008 2:30:00 PM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Thienemanniella	9		
Thienemannimyia grp.	2	3	1
Zavrelimyia		3	3
<b>EPHEMEROPTERA</b>			
Baetis	22		
Caenis latipennis	1	196	31
Heptageniidae			1
Stenonema femoratum	12	36	3
<b>HEMIPTERA</b>			
Belostoma		1	-99
<b>ISOPODA</b>			
Caecidotea	91	40	146
<b>LIMNOPHILA</b>			
Physella	3	8	18
<b>ODONATA</b>			
Argia			2
Boyeria			-99
Enallagma			7
Ischnura		1	
Nasiaeschna pentacantha			-99
<b>TRICHOPTERA</b>			
Cheumatopsyche	19		2
Chimarra	1		
Hydroptila	1		
Ptilostomis		1	
Triaenodes			1
<b>TUBIFICIDA</b>			
Enchytraeidae		1	1
Tubificidae	3	33	
<b>VENEROIDA</b>			
Pisidiidae		1	

**Aquid Invertebrate Database Bench Sheet Report**

**Big Cr [0804094], Station #1, Sample Date: 9/29/2008 5:30:00 PM**

**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
<b>"HYDRACARINA"</b>			
Acarina		1	1
<b>AMPHIPODA</b>			
Crangonyx	2	1	1
Hyalella azteca		1	11
<b>COLEOPTERA</b>			
Berosus		2	
Dubiraphia		2	4
Ectopria nervosa	-99		
Stenelmis	42	22	2
<b>DECAPODA</b>			
Orconectes virilis			1
<b>DIPTERA</b>			
Ablabesmyia	1	10	1
Anopheles			6
Ceratopogoninae		1	
Chironomidae	6	6	
Chironomus	1	3	1
Chrysops			1
Cladotanytarsus	7	20	
Corynoneura	2	1	1
Cricotopus bicinctus	52	7	11
Cricotopus/Orthocladius	53	1	8
Cryptochironomus		3	
Dicrotendipes			8
Ephydriidae			1
Glyptotendipes			1
Gonomyia	3		
Hemerodromia	2		
Hexatoma	1	1	
Labrundinia	4		11
Microtendipes	1	4	
Nanocladius	1	1	
Nilotanypus	1		1
Paracladopelma			1
Parametriocnemus	1		
Paratanytarsus		8	11
Paratendipes	1	21	
Phaenopsectra	2	4	1
Polypedilum	1		
Polypedilum aviceps	1		
Polypedilum convictum	69		
Polypedilum halterale grp		3	
Polypedilum illinoense grp	32		10
Polypedilum scalaenum grp	6	9	
Pseudochironomus			1
Rheocricotopus	1		
Rheotanytarsus	38		3

**Aquid Invertebrate Database Bench Sheet Report**  
**Big Cr [0804094], Station #1, Sample Date: 9/29/2008 5:30:00 PM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Simulium	93	4	
Stempellinella	1		1
Stictochironomus		21	
Tanytarsus	27	45	28
Thienemanniella	47		
Thienemannimyia grp.	6		1
Tribelos		2	
Zavrelimyia	4	1	1
<b>EPHEMEROPTERA</b>			
Acentrella	11		
Acerpenna	11		
Baetis	52		
Caenis latipennis	13	55	169
Centroptilum		1	1
Paracloeodes		1	
Procloeon		1	1
Stenacron		2	1
Stenonema femoratum	34	42	5
Tricorythodes			1
<b>HEMIPTERA</b>			
Microvelia			1
Trepobates			1
<b>LIMNOPHILA</b>			
Physella			6
<b>ODONATA</b>			
Argia			1
Basiaeschna janata			1
Calopteryx			1
Corduliidae		1	
Dromogomphus		1	
Enallagma		1	10
<b>PLECOPTERA</b>			
Perlesta	6		
<b>TRICHOPTERA</b>			
Cheumatopsyche	65		
Chimarra	3		
Phryganeidae		1	
Triaenodes			5
<b>TUBIFICIDA</b>			
Tubificidae		1	
<b>VENEROIDA</b>			
Pisidiidae			1

**Aquid Invertebrate Database Bench Sheet Report**

Sugar Cr [0804095], Station #1, Sample Date: 9/30/2008 10:00:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
AMPHIPODA			
<i>Crangonyx</i>	17	44	2
<i>Gammarus</i>	-99	1	-99
COLEOPTERA			
<i>Dubiraphia</i>			3
<i>Dytiscidae</i>			1
<i>Helichus basalis</i>			5
<i>Heterosternuta</i>			6
<i>Hydraena</i>		1	
<i>Stenelmis</i>	1	8	1
DECAPODA			
<i>Orconectes virilis</i>			-99
DIPTERA			
<i>Ablabesmyia</i>		8	2
<i>Anopheles</i>			2
<i>Ceratopogoninae</i>		1	
<i>Chironomidae</i>	4	1	7
<i>Chironomus</i>			3
<i>Corynoneura</i>		1	6
<i>Cricotopus bicinctus</i>	1		29
<i>Cricotopus/Orthocladius</i>	9	3	21
<i>Cryptochironomus</i>		2	1
<i>Dicrotendipes</i>			4
<i>Eukiefferiella</i>	5		
<i>Hemerodromia</i>	1	1	
<i>Hexatoma</i>	2	2	
<i>Labrundinia</i>			8
<i>Micropsectra</i>			2
<i>Microtendipes</i>	1	5	1
<i>Nanocladius</i>			1
<i>Nilotanypus</i>			1
<i>Parakiefferiella</i>			1
<i>Parametriocnemus</i>	1		
<i>Paratanytarsus</i>		3	30
<i>Paratendipes</i>		9	1
<i>Phaenopsectra</i>			2
<i>Polypedilum aviceps</i>			1
<i>Polypedilum convictum</i>	31		3
<i>Polypedilum illinoense grp</i>			11
<i>Rheotanytarsus</i>	2		15
<i>Simulium</i>	181		10
<i>Stictochironomus</i>		8	2
<i>Tanytarsus</i>	1	12	64
<i>Thienemanniella</i>	7		2
<i>Thienemannimyia grp.</i>			2
<i>Zavrelimyia</i>		1	3
EPHEMEROPTERA			
<i>Acerpenna</i>	1		

**Aquid Invertebrate Database Bench Sheet Report****Sugar Cr [0804095], Station #1, Sample Date: 9/30/2008 10:00:00 AM****CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Baetis	68		
Caenis latipennis		26	27
Callibaetis			5
Centroptilum		1	
Stenacron		5	
Stenonema femoratum	10	138	3
<b>HEMIPTERA</b>			
Aquarius			-99
Belostoma			2
Microvelia			5
<b>ISOPODA</b>			
Caecidotea	29	15	48
Caecidotea (Blind & Unpigmented)		1	
<b>LEPIDOPTERA</b>			
Crambidae			-99
<b>LIMNOPHILA</b>			
Physella			6
<b>LUMBRICINA</b>			
Lumbricina	1		
<b>ODONATA</b>			
Basiaeschna janata			1
Enallagma			1
Epiæschna heros			-99
<b>PLECOPTERA</b>			
Perlesta	2		
<b>TRICHOPTERA</b>			
Cheumatopsyche	159		1
Chimarra			2
<b>TRICLADIDA</b>			
Planariidae	1		
<b>TUBIFICIDA</b>			
Enchytraeidae			1
Limnodrilus hoffmeisteri		1	
Tubificidae	1	2	

**Aquid Invertebrate Database Bench Sheet Report**

Hays Cr [0804096], Station #1a, Sample Date: 9/30/2008 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Crangonyx	11	3	29
Gammarus	4		2
COLEOPTERA			
Dubiraphia			2
Dytiscidae	1		2
Helichus basalis	2		1
Helichus lithophilus			1
Stenelmis	51	6	
DECAPODA			
Orconectes virilis	2		
DIPTERA			
Ablabesmyia	5	3	1
Anopheles			3
Ceratopogoninae	1	1	
Chironomidae		1	
Chironomus	3	4	1
Cladotanytarsus	2		
Corynoneura		3	
Cricotopus bicinctus	6	1	3
Cricotopus/Orthocladius	14		
Cryptochironomus	2	2	
Demicryptochironomus	1		
Dicrotendipes		2	10
Diptera	3		
Eukiefferiella	1		
Hemerodromia	2		
Hexatoma	4		
Labrundinia			2
Larsia			1
Microtendipes	1	10	4
Nilotanypus	2		
Ormosia		1	
Paracladopelma	1	1	
Parametriocnemus	3		
Paratanytarsus	2	3	32
Paratendipes	7	9	
Phaenopsectra		2	4
Polypedilum convictum	81		1
Polypedilum fallax grp	1		1
Polypedilum illinoense grp	24	1	13
Polypedilum scalaenum grp		3	
Rheocricotopus	1		
Rheotanytarsus	30	1	1
Simulium	47		
Stempellinella	1	1	1

**Aquid Invertebrate Database Bench Sheet Report****Hays Cr [0804096], Station #1a, Sample Date: 9/30/2008 2:30:00 PM****CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Stictochironomus	2	5	
Tanytarsus	72	28	32
Thienemanniella	14		
Thienemannimyia grp.	6		
Zavrelimyia	1	1	
<b>EPHEMEROPTERA</b>			
Acerpenna	1		
Baetis	29		
Caenis latipennis	152	152	150
Callibaetis			1
Procloeon			1
Stenacron		1	1
Stenonema femoratum	57	28	14
<b>ISOPODA</b>			
Caecidotea	8	1	19
<b>LIMNOPHILA</b>			
Physella	3	1	
<b>ODONATA</b>			
Argia		1	
Calopteryx			-99
Enallagma			3
Somatochlora			1
<b>PLECOPTERA</b>			
Perlesta	4		
<b>TRICHOPTERA</b>			
Cheumatopsyche	111		
<b>TRICLADIDA</b>			
Planariidae			1
<b>TUBIFICIDA</b>			
Branchiura sowerbyi	2	1	
Enchytraeidae	2	1	2
Tubificidae	23		1
<b>VENEROIDA</b>			
Pisidiidae	1		

**Aquid Invertebrate Database Bench Sheet Report**

Hays Cr [0804097], Station #1b, Sample Date: 9/30/2008 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	1
AMPHIPODA			
Crangonyx	8	1	7
Gammarus	1		
Hyalella azteca			1
COLEOPTERA			
Helichus basalis	1		2
Neoporus			2
Stenelmis	25	2	3
DIPTERA			
Ablabesmyia	2	5	
Chironomidae	2	2	1
Chironomus	5	3	1
Cladotanytarsus	1	1	
Corynoneura	2		
Cricotopus bicinctus	4		3
Cricotopus/Orthocladius	10		1
Cryptochironomus	1	1	
Dicrotendipes		2	4
Diptera		1	-99
Hemerodromia	4		1
Hexatoma	4		
Labrundinia			1
Microtendipes	3	8	2
Parametriocnemus	7		
Paratanytarsus	2		25
Paratendipes	2	1	1
Phaenopsectra	1	3	2
Polypedilum convictum	91		1
Polypedilum halterale grp		1	
Polypedilum illinoense grp	29	2	7
Polypedilum scalaenum grp	5		
Rheocricotopus	1		
Rheotanytarsus	21		1
Saetheria	1		
Simulium	81	1	
Stempellinella	1		
Stictochironomus	1	1	2
Tanytarsus	70	20	23
Thienemanniella	14		
Thienemannimyia grp.	1		
Zavrelimyia	1	1	
EPHEMEROPTERA			
Baetis	39		1
Caenis latipennis	103	195	172
Callibaetis			1
Stenonema femoratum	46	53	10

**Aquid Invertebrate Database Bench Sheet Report****Hays Cr [0804097], Station #1b, Sample Date: 9/30/2008 2:30:00 PM****CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
ISOPODA			
Caecidotea	6		7
LIMNOPHILA			
Physella	2		5
ODONATA			
Argia			2
Basiaeschna janata			1
Calopteryx			-99
Enallagma			-99
Libellula			-99
PLECOPTERA			
Perlidae	2		
TRICHOPTERA			
Cheumatopsyche	92	1	2
Chimarra	1		
Hydropsyche	1		
TUBIFICIDA			
Enchytraeidae			2
Tubificidae	4	2	1
VENEROIDA			
Pisidiidae			1

**Aquid Invertebrate Database Bench Sheet Report**

**Brush Cr [0804098], Station #1, Sample Date: 9/30/2008 5:30:00 PM**

**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Crangonyx	3		
Halella azteca			37
COLEOPTERA			
Berosus			1
Dubiraphia		3	4
Dytiscidae		1	1
Helichus lithophilus			1
Peltodytes			1
Scirtidae			1
Stenelmis	4	2	
DECAPODA			
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		11	3
Anopheles			1
Ceratopogoninae	1	3	1
Chironomus		6	
Cladotanytarsus	2	3	
Corynoneura	6	3	2
Cricotopus bicinctus		1	3
Cricotopus/Orthocladius	5	3	3
Cryptochironomus		4	
Dicrotendipes		2	2
Diptera	1		1
Eukiefferiella	2		
Gonomyia			1
Hemerodromia	2		1
Hexatoma	2		
Hydrobaenus	1		1
Krenosmittia	1		
Labrundinia	1	3	
Microtendipes		3	4
Nanocladius			1
Paracladopelma	1		
Parametriocnemus	14		
Paratanytarsus		13	24
Paratendipes		35	3
Phaenopsectra	3	16	
Polypedilum convictum	37	1	3
Polypedilum fallax grp			1
Polypedilum illinoense grp	47	6	19
Polypedilum scalaenum grp	2	8	4
Rheocricotopus	1		
Rheotanytarsus	13	1	11
Simulium	117		

**Aquid Invertebrate Database Bench Sheet Report****Brush Cr [0804098], Station #1, Sample Date: 9/30/2008 5:30:00 PM****CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Stempellinella		3	1
Stictochironomus		3	
Tabanus		-99	
Tanytarsus	20	61	46
Thienemanniella	37		5
Thienemannimyia grp.	4	3	1
<b>EPHEMEROPTERA</b>			
Acentrella	4		
Acerpenna	3		
Baetis	116		
Caenis latipennis	18	95	123
Procloeon		3	
Stenonema femoratum	20	18	6
Tricorythodes	1		
<b>ISOPODA</b>			
Caecidotea		2	5
<b>LIMNOPHILA</b>			
Physella		4	2
<b>ODONATA</b>			
Basiaeschna janata			-99
Enallagma			4
<b>PLECOPTERA</b>			
Perlesta	6		
<b>TRICHOPTERA</b>			
Cheumatopsyche	158		
Triaenodes		1	4
<b>TUBIFICIDA</b>			
Enchytraeidae	1	2	3
Tubificidae		1	1
<b>VENEROIDA</b>			
Pisidiidae	1		

**Aquid Invertebrate Database Bench Sheet Report**

Grassy Cr [0804099], Station #1, Sample Date: 10/1/2008 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
"HYDRACARINA"			
Acarina			7
AMPHIPODA			
Crangonyx	25		47
Gammarus			6
Hyalella azteca			1
COLEOPTERA			
Dubiraphia			2
Heterosternuta			1
Peltodytes			1
Scirtidae			5
Stenelmis	2	2	3
DECAPODA			
Orconectes luteus			-99
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		11	1
Aedes			1
Chironomus	2	5	
Cladotanytarsus		1	
Corynoneura		8	1
Cricotopus bicinctus	2		1
Cricotopus/Orthocladius	1	1	1
Cryptochironomus		2	
Dicrotendipes		2	2
Diptera	1	1	
Hexatoma	2		
Labrundinia		1	3
Microtendipes		6	1
Parametriocnemus	2		
Paratanytarsus		2	3
Paratendipes		20	1
Phaenopsectra		51	4
Polypedilum convictum	20		
Polypedilum fallax grp			1
Polypedilum illinoense grp	14	14	18
Polypedilum scalaenum grp		2	
Rheotanytarsus	1		
Sciomyzidae			1
Simulium	320	1	5
Stempellinella		1	
Tanytarsus	5	63	21
Thienemanniella	5	1	
Thienemannimyia grp.			5
Tribelos		3	
Zavrelimyia	1	2	1
EPHEMEROPTERA			
Acentrella	6		2

**Aquid Invertebrate Database Bench Sheet Report**  
**Grassy Cr [0804099], Station #1, Sample Date: 10/1/2008 12:00:00 PM**  
**CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence**

<b>ORDER: TAXA</b>	<b>CS</b>	<b>NF</b>	<b>RM</b>
Baetis	128		1
Caenis latipennis		57	124
Callibaetis			4
Centroptilum		2	4
Heptageniidae		6	
Stenacron			1
Stenonema femoratum	3	15	13
Tricorythodes			1
<b>HEMIPTERA</b>			
Belostoma			-99
Corixidae		1	
Microvelia			1
<b>ISOPODA</b>			
Caecidotea	-99	2	3
<b>LIMNOPHILA</b>			
Helisoma			1
Lymnaeidae		2	
Menetus		1	
Physella	1	1	16
<b>ODONATA</b>			
Argia			2
Enallagma			4
Ischnura			5
<b>PLECOPTERA</b>			
Perlidae	1		
<b>RHYNCHOBDELLIDA</b>			
Glossiphoniidae			-99
<b>TRICHOPTERA</b>			
Cheumatopsyche	81		
Hydropsyche	1		
<b>TUBIFICIDA</b>			
Enchytraeidae	1		
Tubificidae		4	